THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

THE INSTITUTION OF

PRODUCTION ENGINEERS JOURNAL

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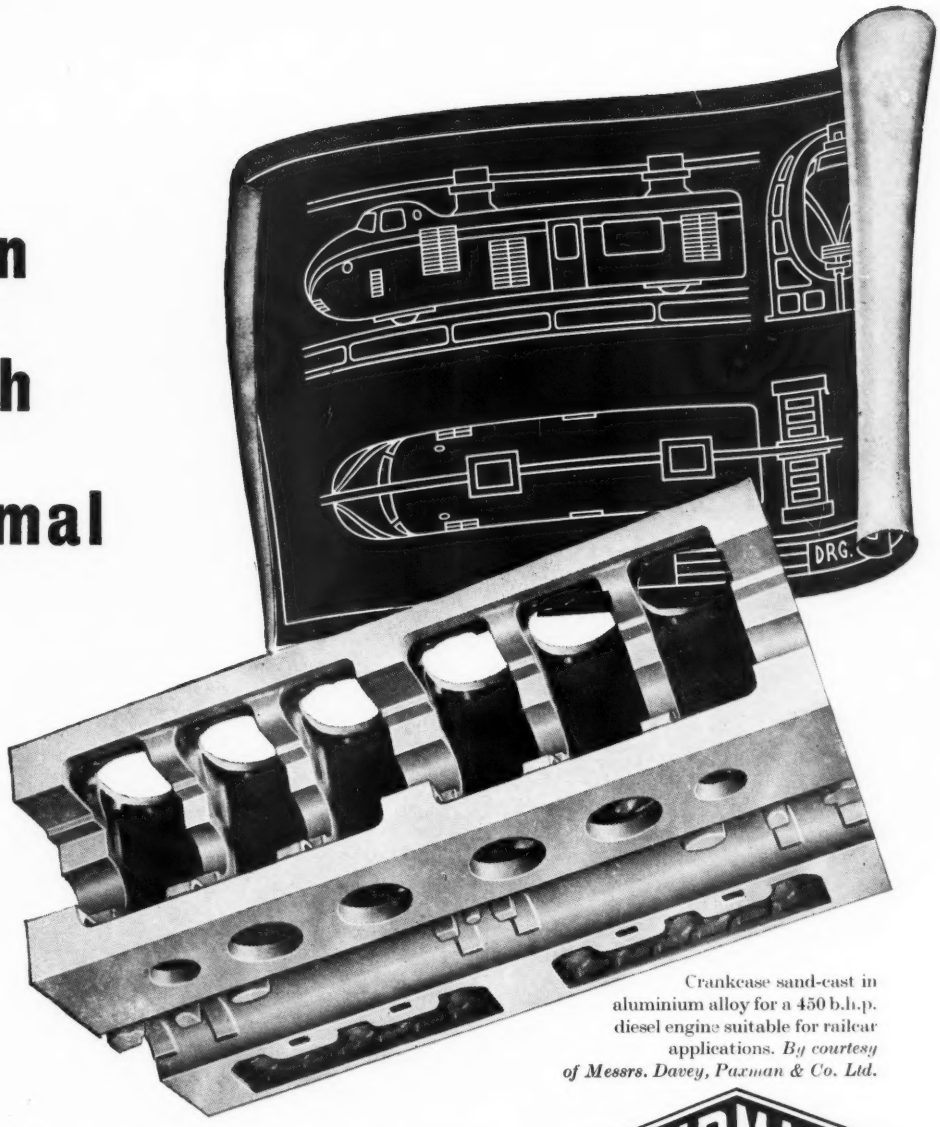

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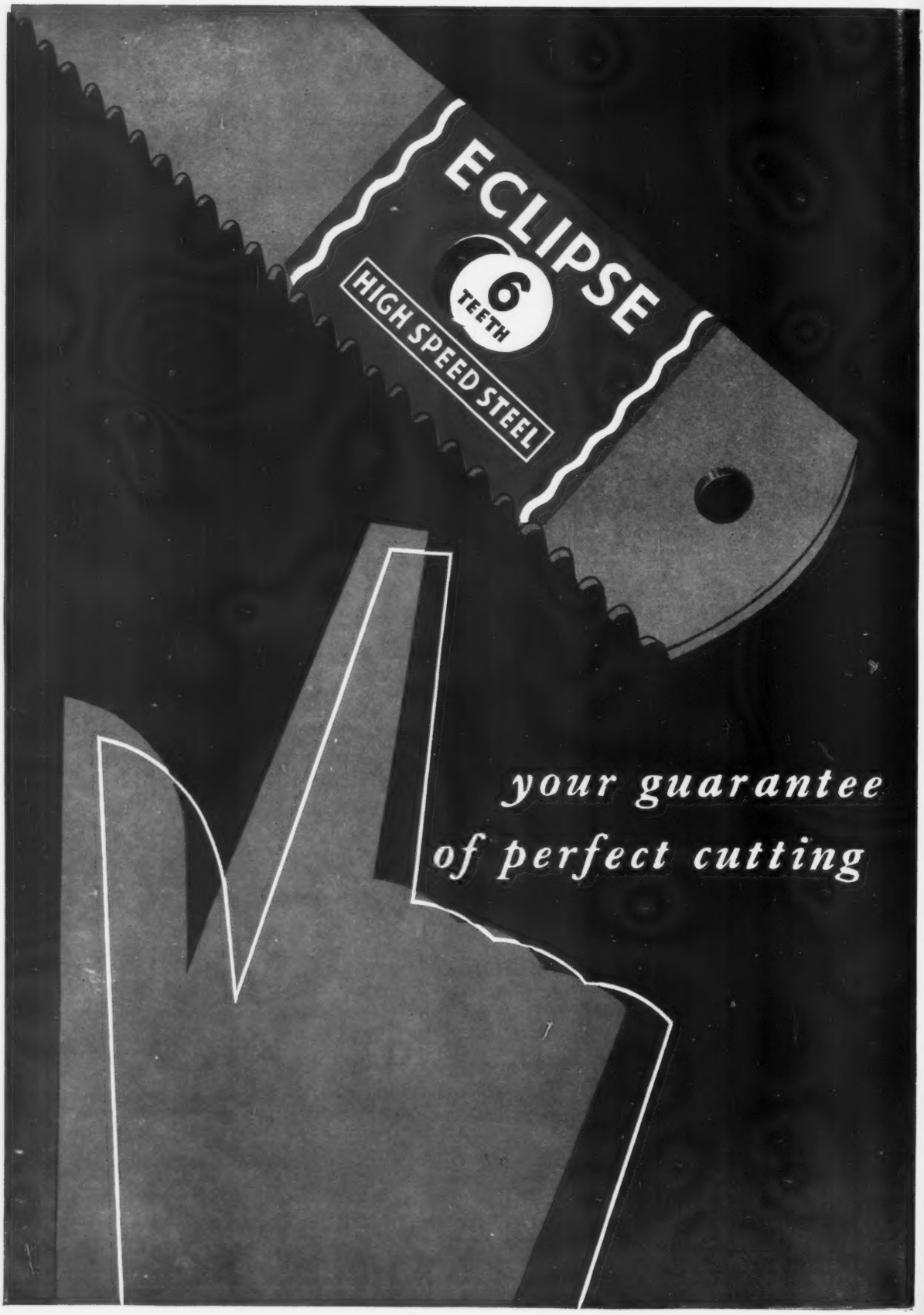

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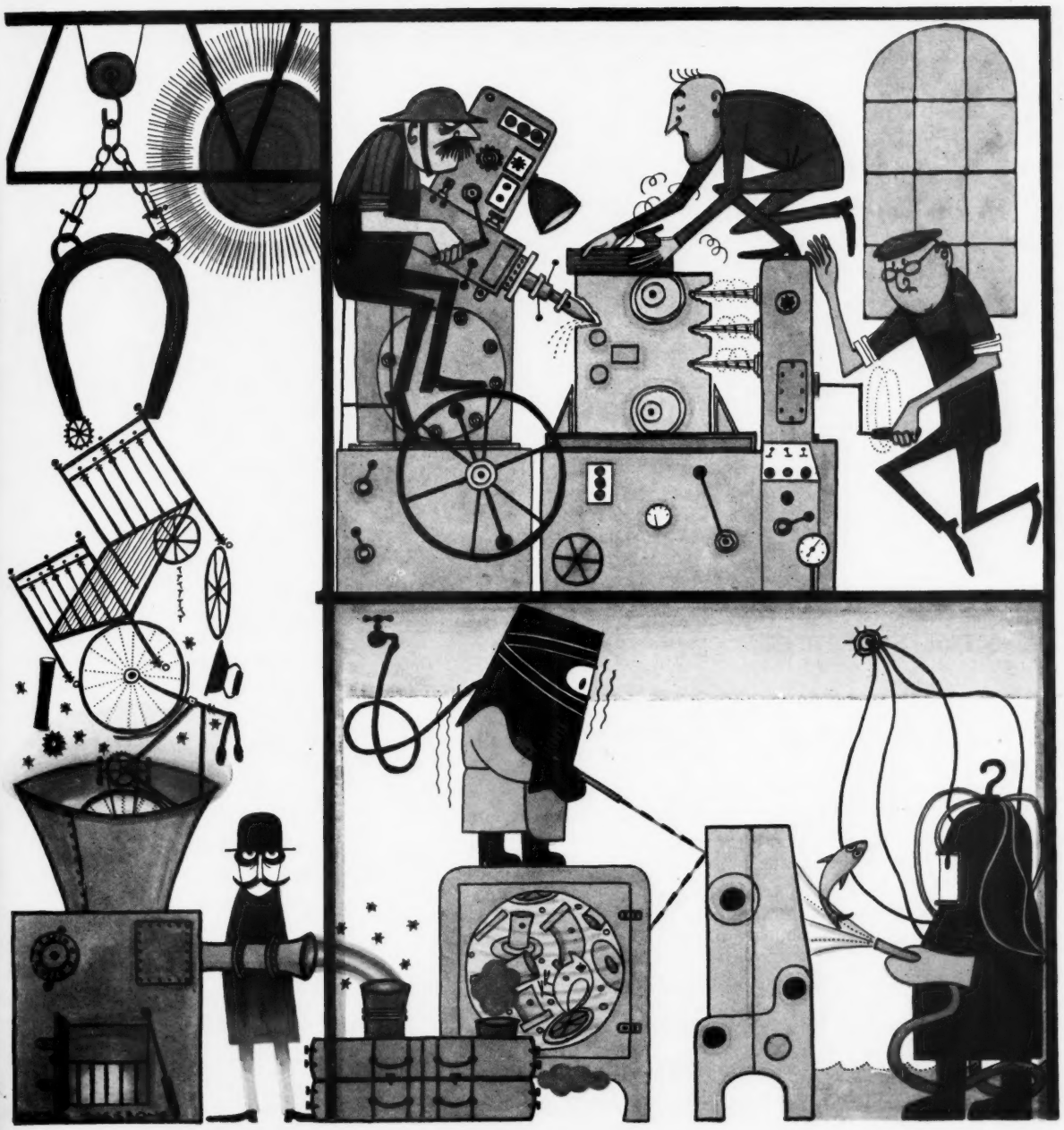

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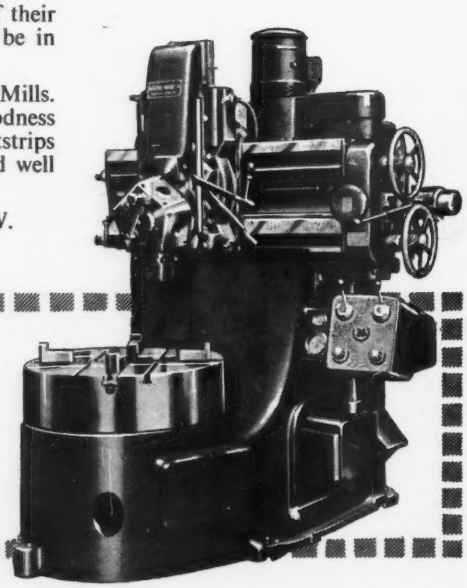

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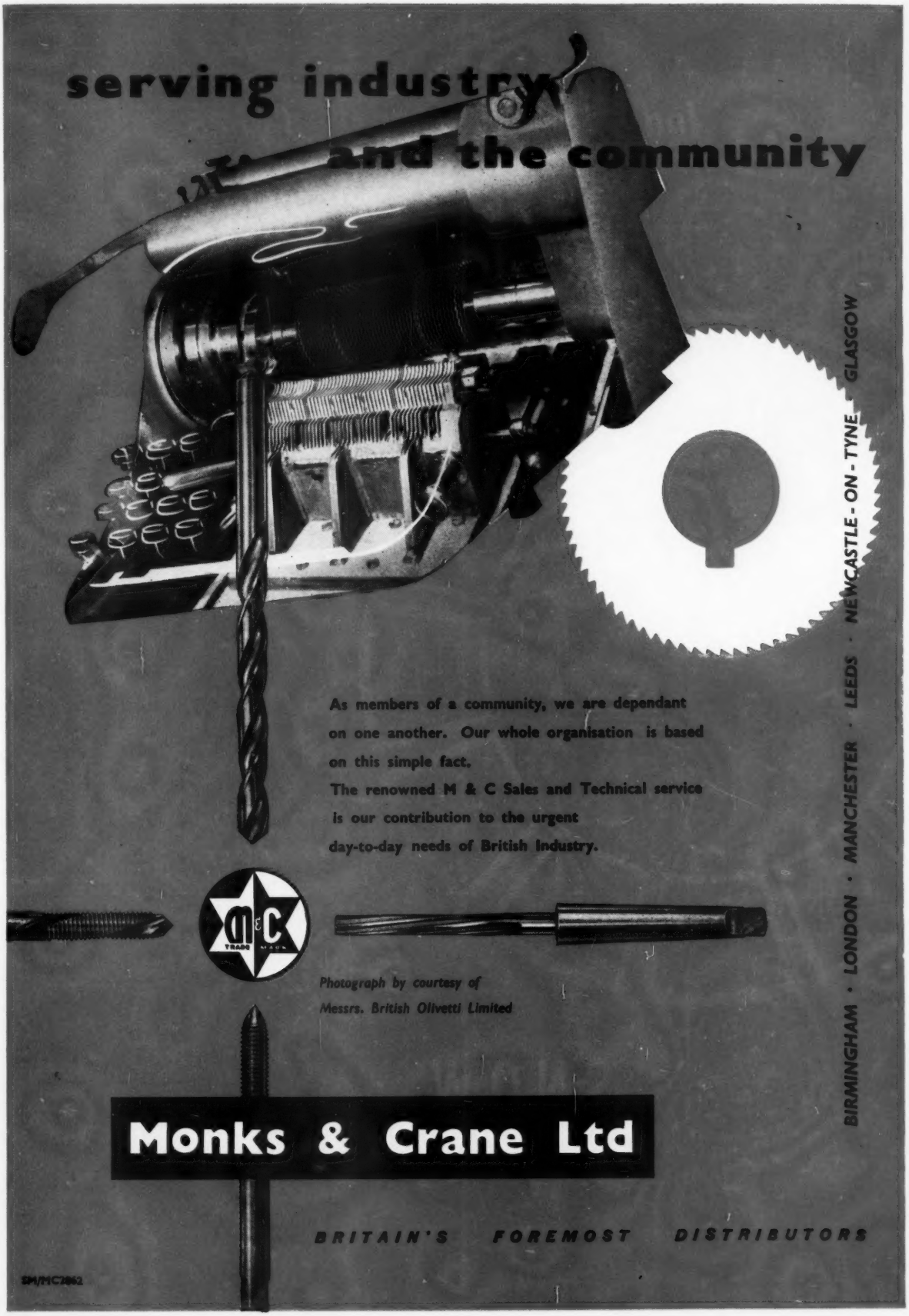
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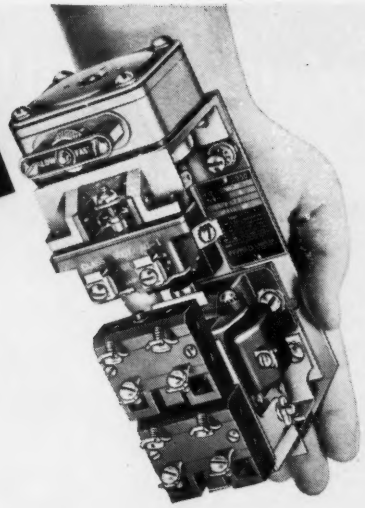

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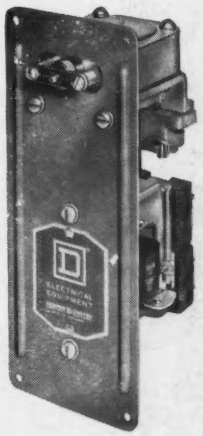

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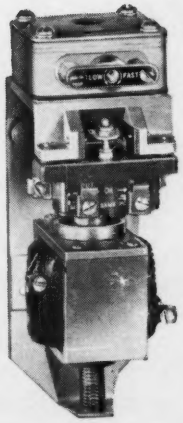

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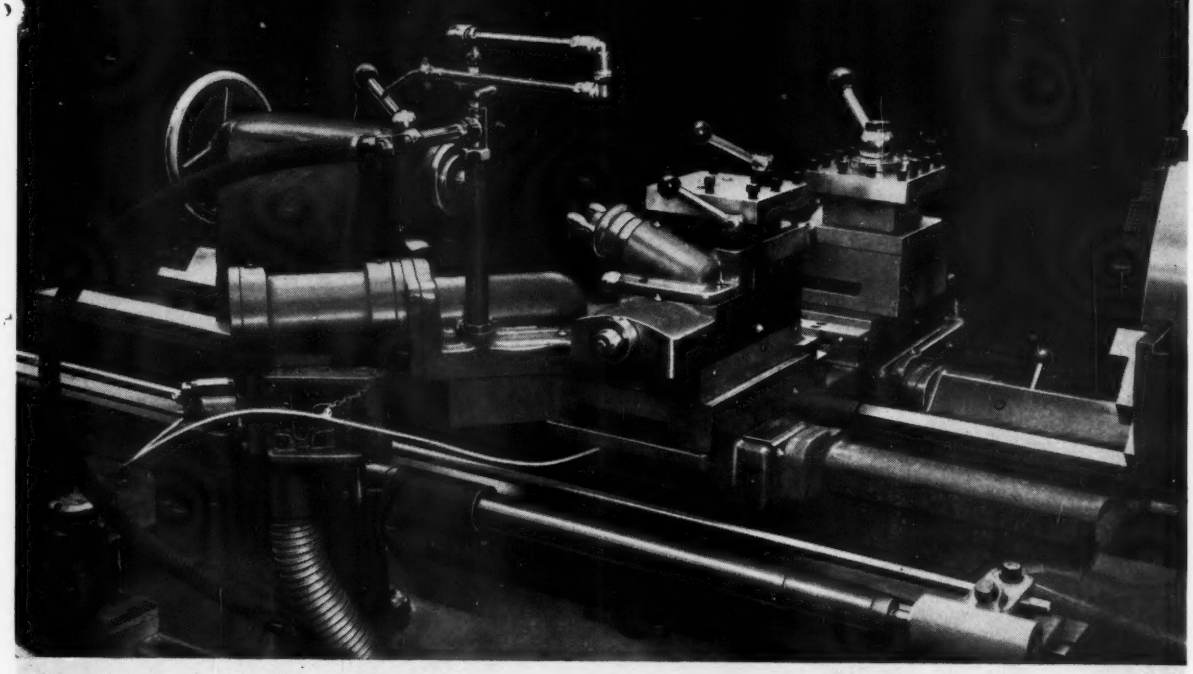

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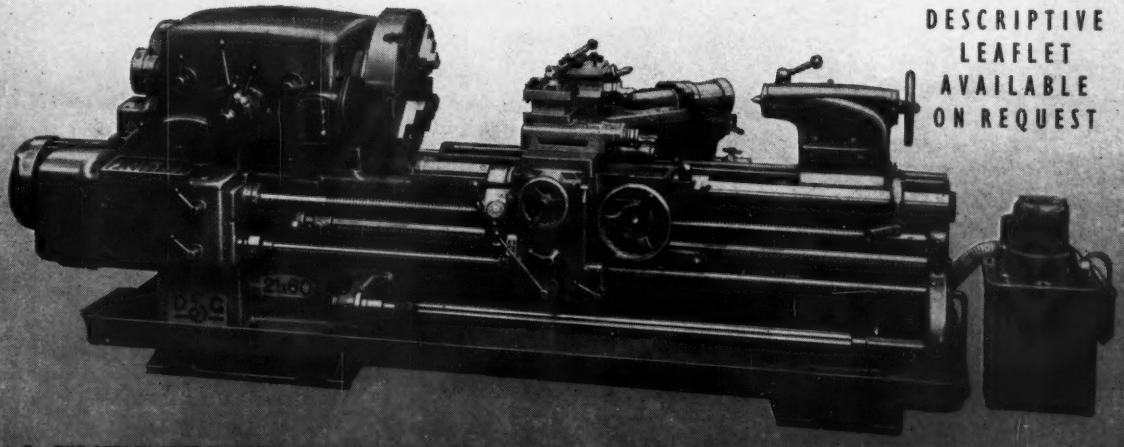

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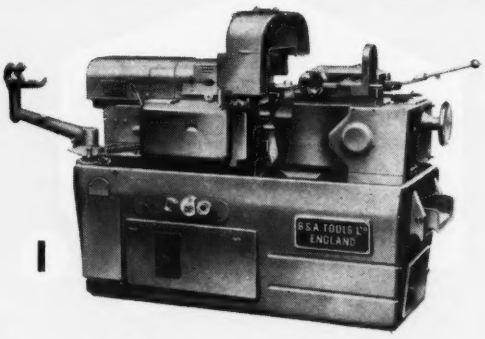

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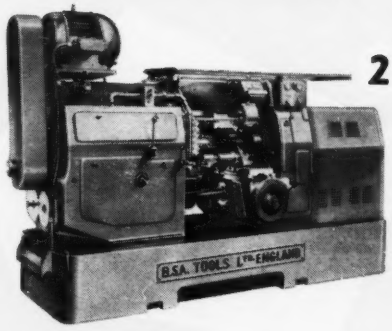

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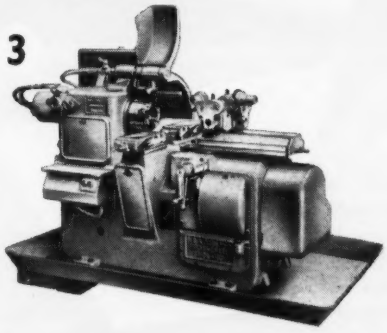

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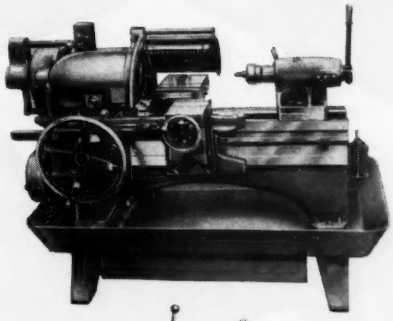

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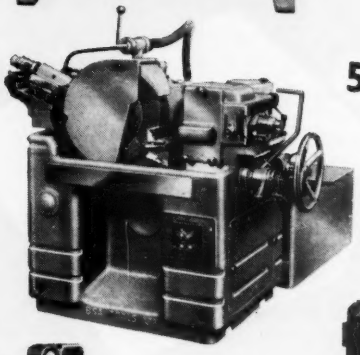

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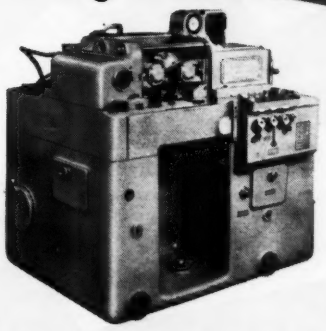

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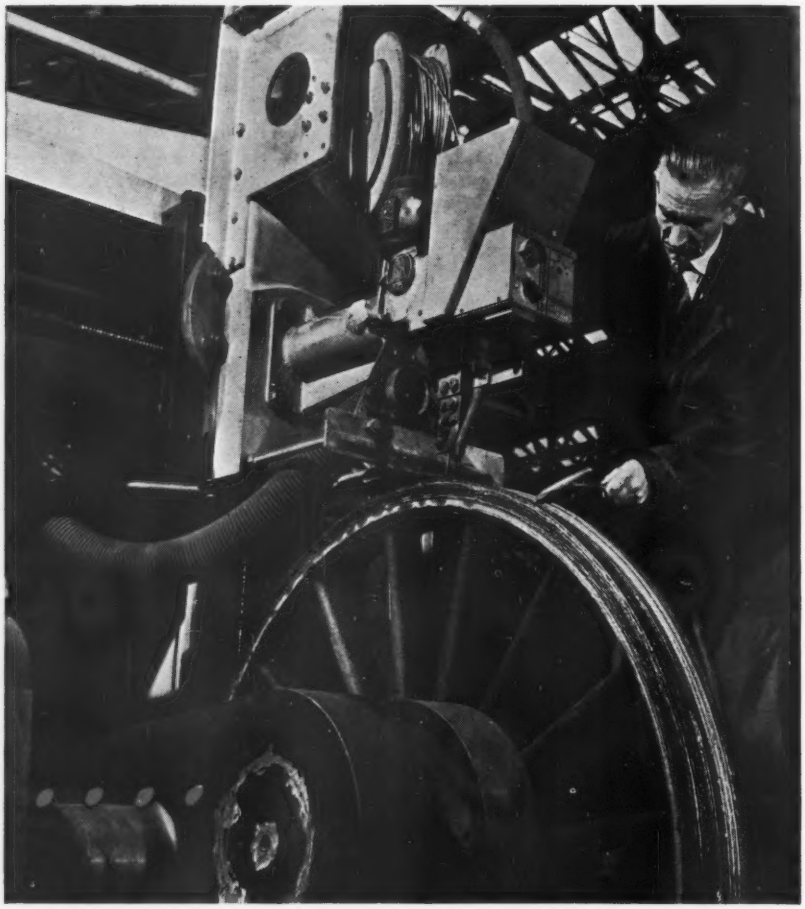

Photograph by courtesy of British Railways Magazine (Southern Region)

To maintain smooth running with maximum safety, British Railways Southern Region keep a constant check on the wheels of their locomotives to ensure that they retain a perfect shape and even surface.

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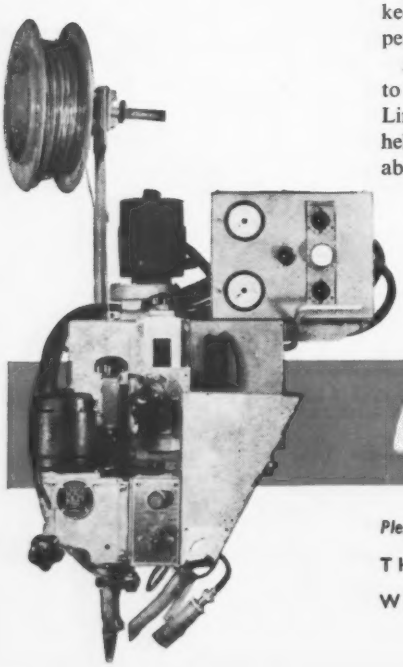

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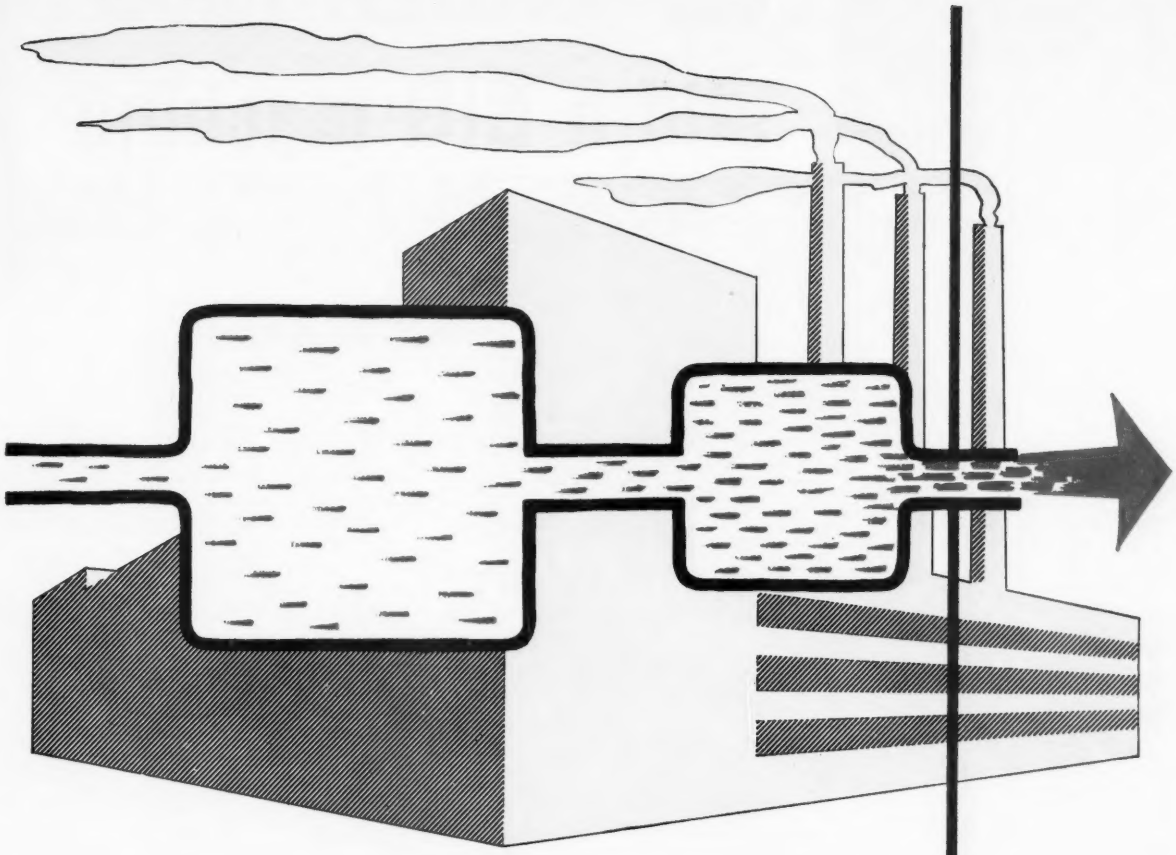

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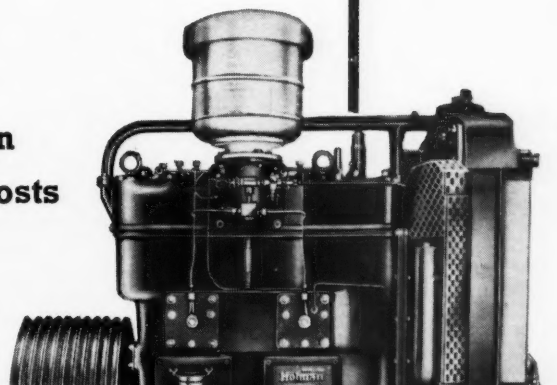

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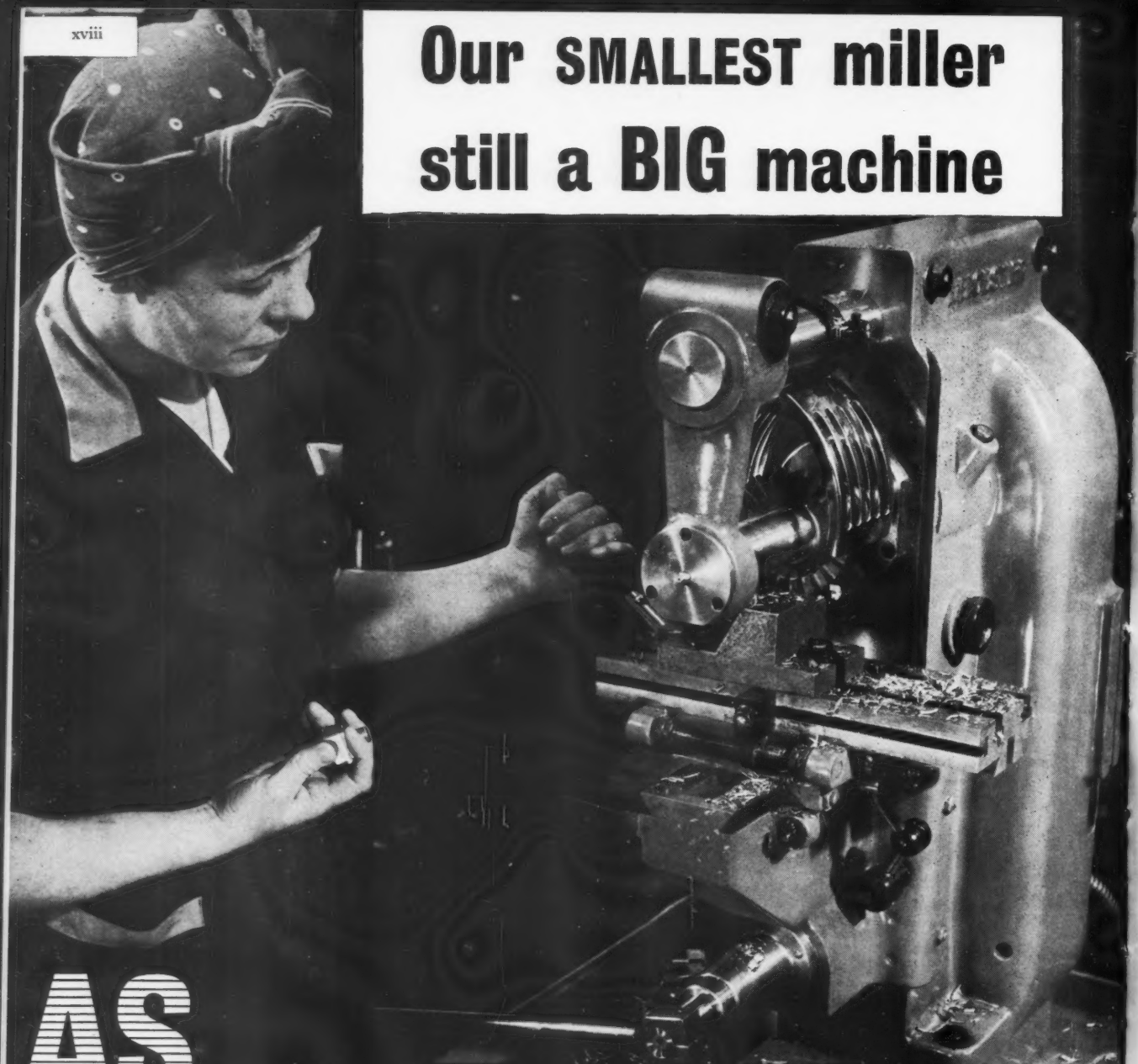

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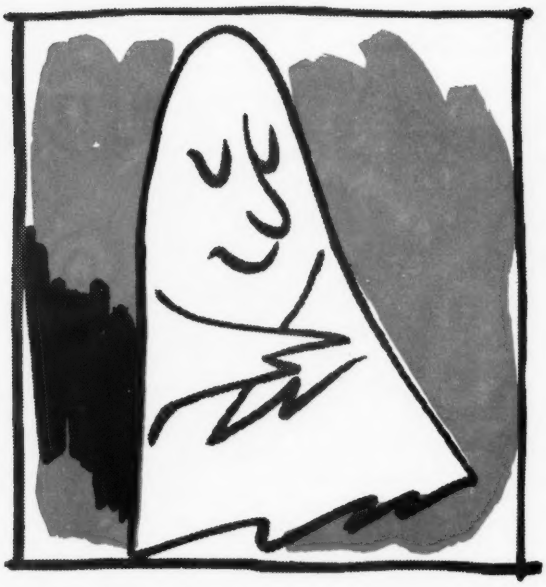

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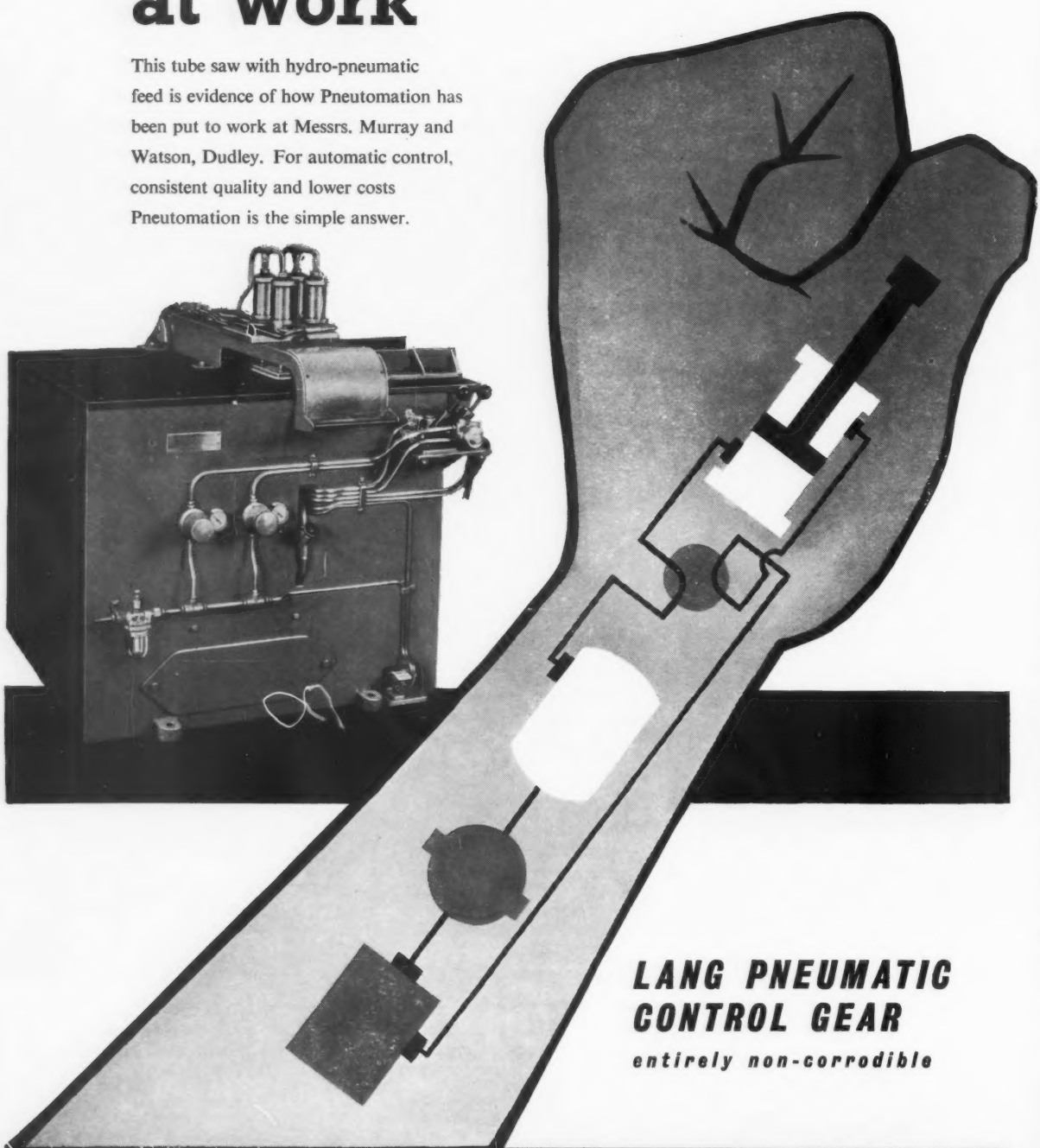

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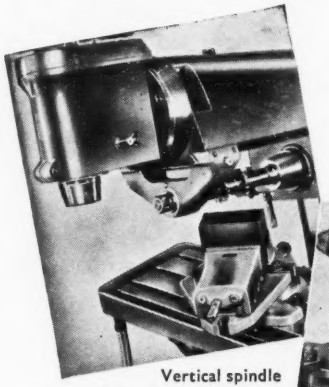
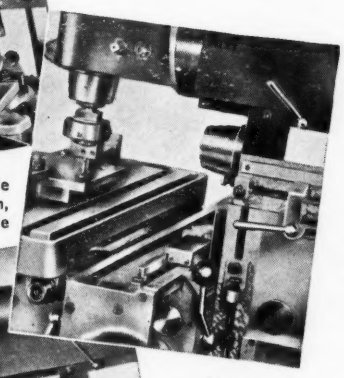
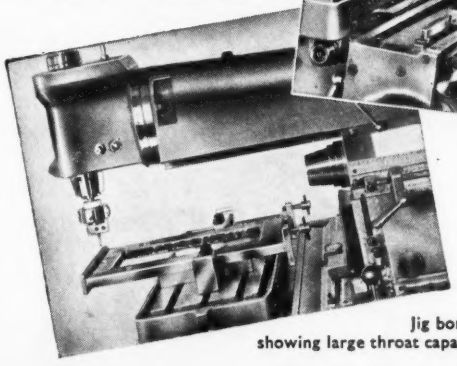


Vertical spindle drive through overarm, independent of horizontal spindle



Close to column jig boring



Jig boring showing large throat capacity

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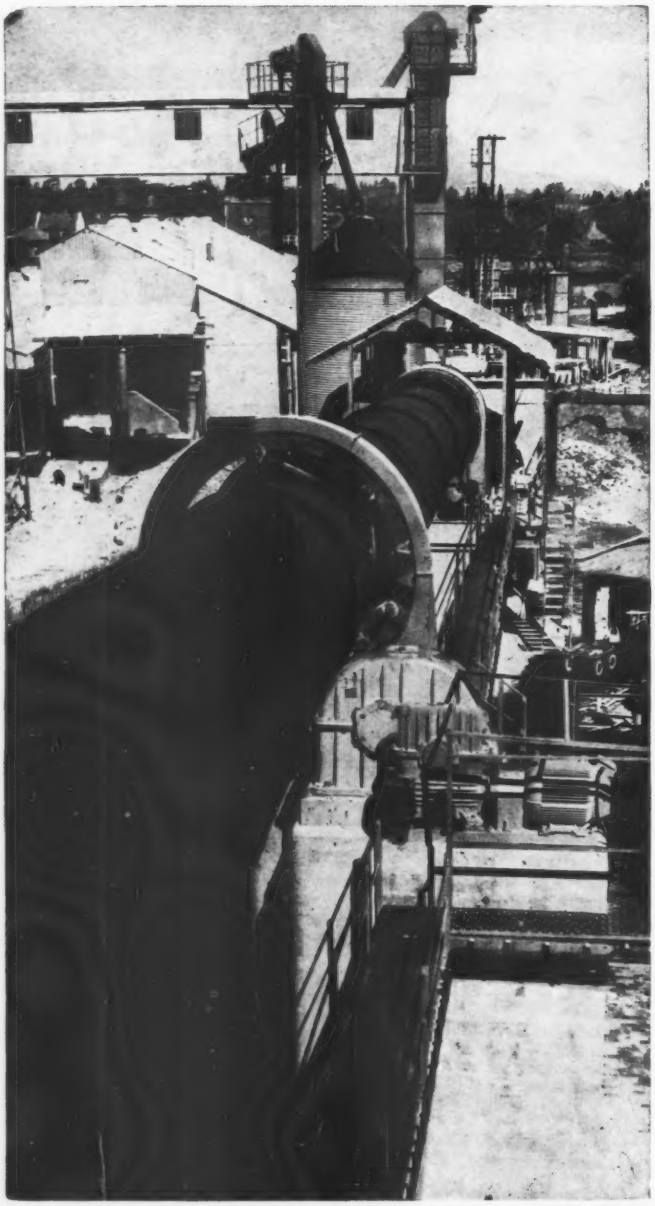

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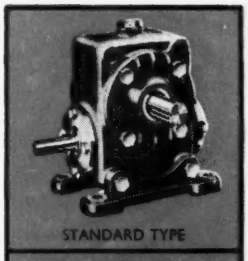
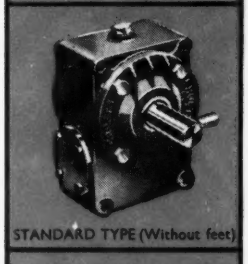
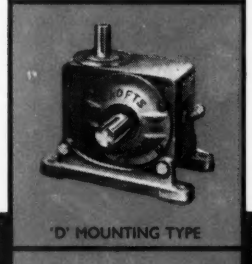
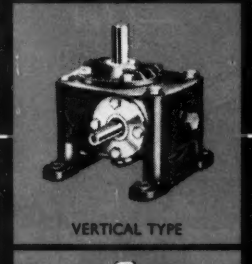
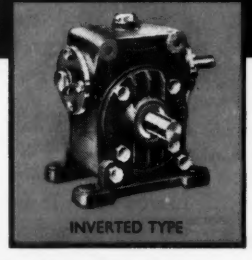
Crofts universal mounting worm reduction gears


STANDARD TYPE


STANDARD TYPE (Without feet)


'D' MOUNTING TYPE


VERTICAL TYPE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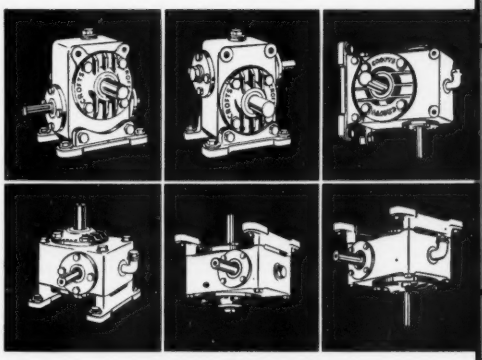

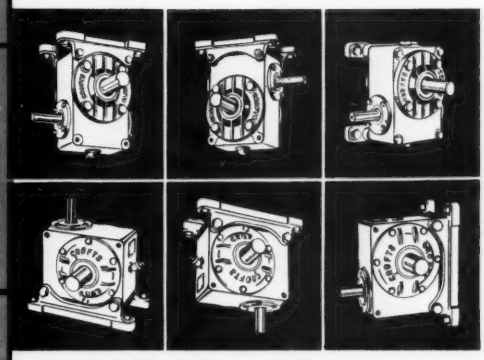

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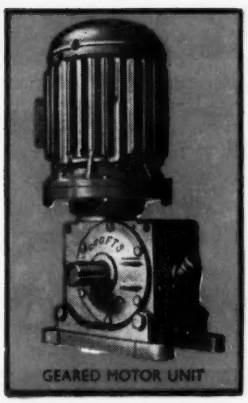
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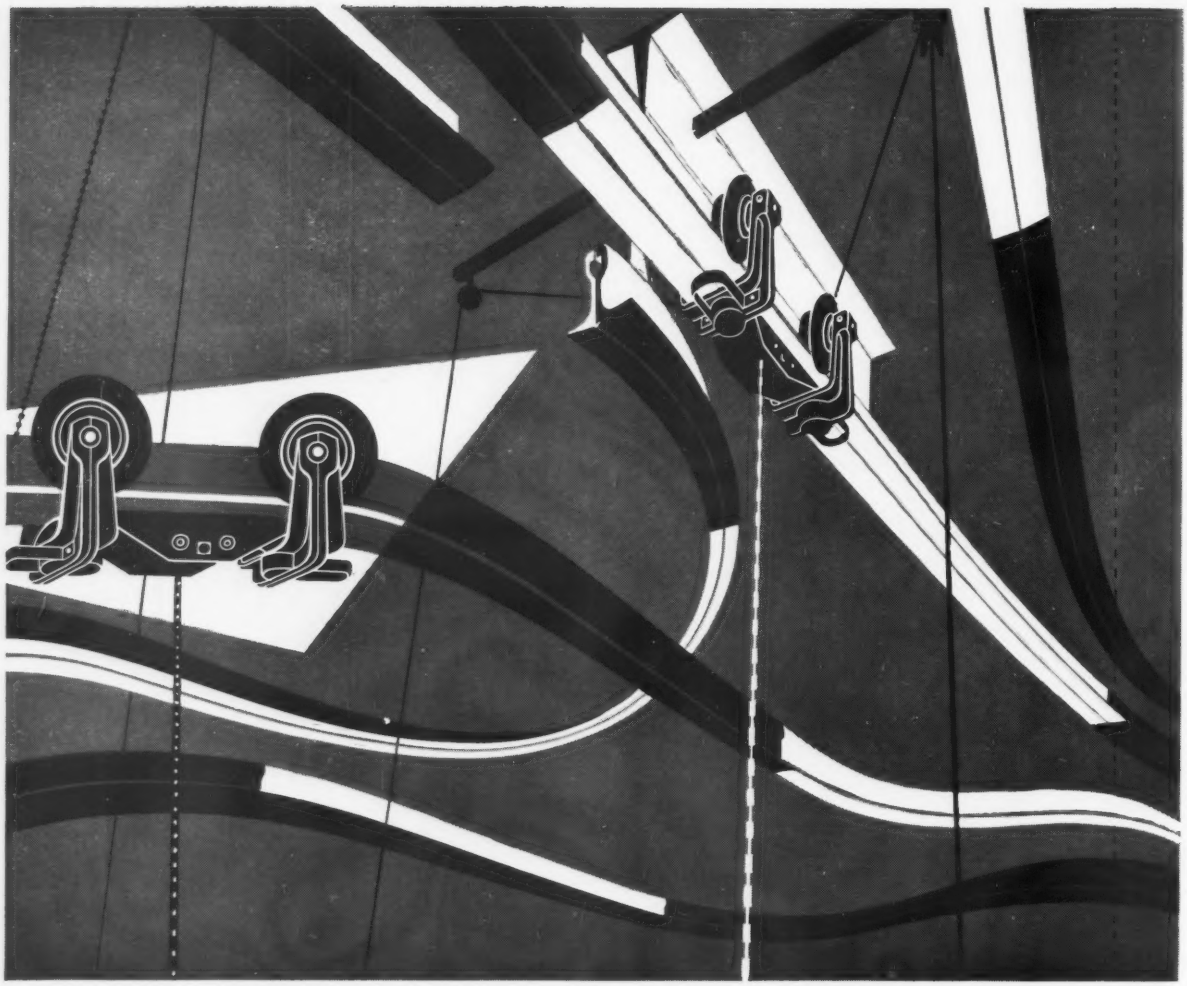

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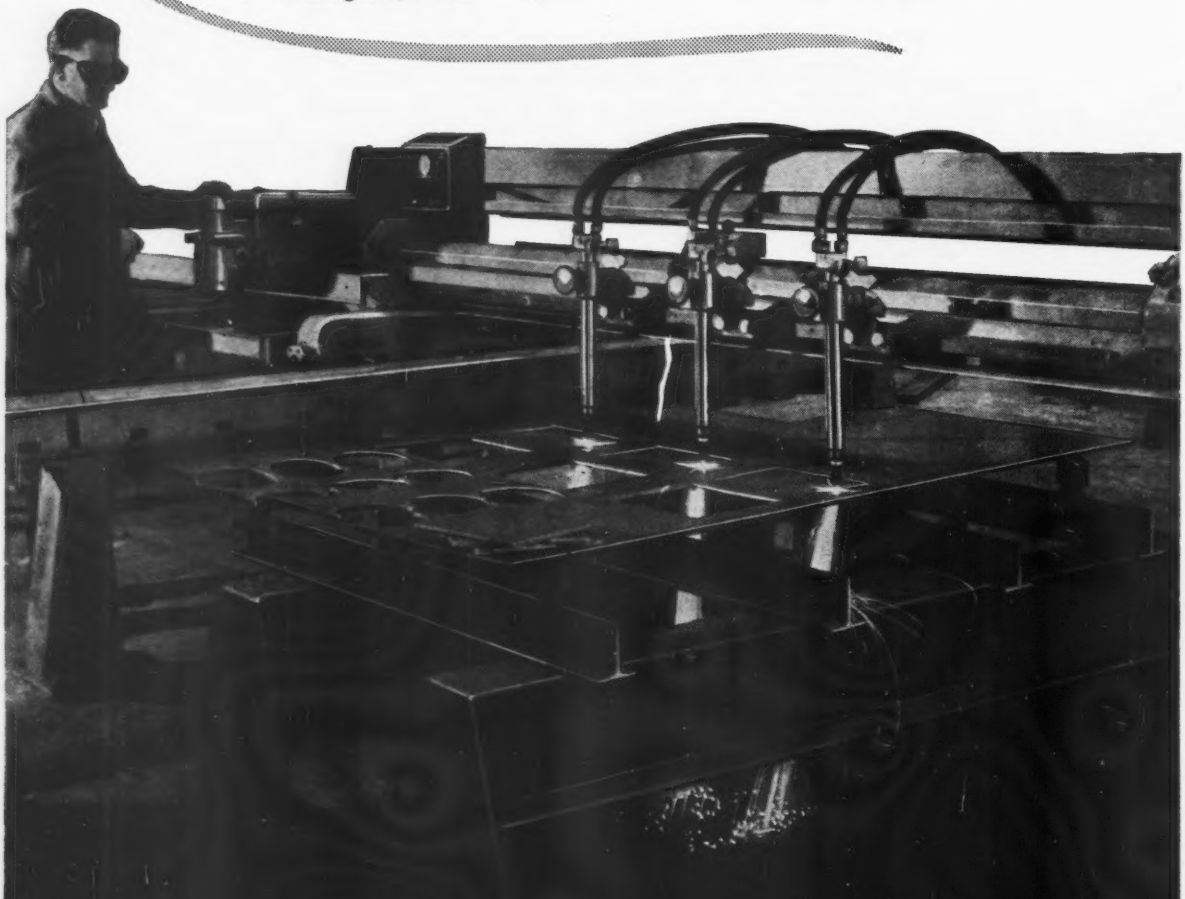
Our illustration shows the Bison in action at the works of Messrs. Sale, Tilney & Company Ltd., Wokingham, Berks.



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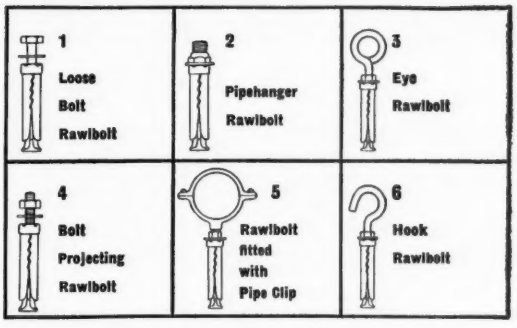

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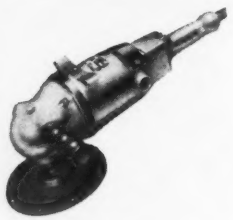

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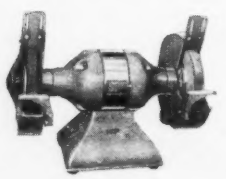

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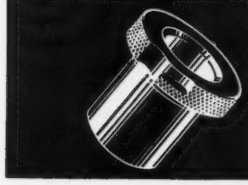

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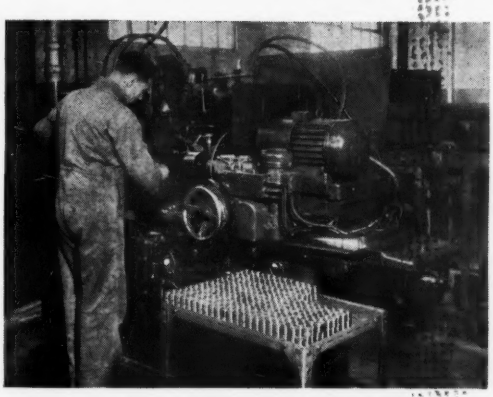

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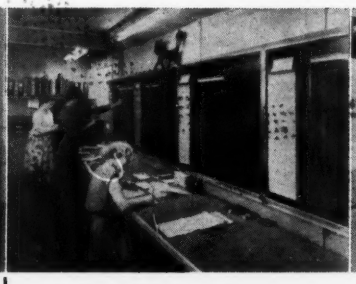

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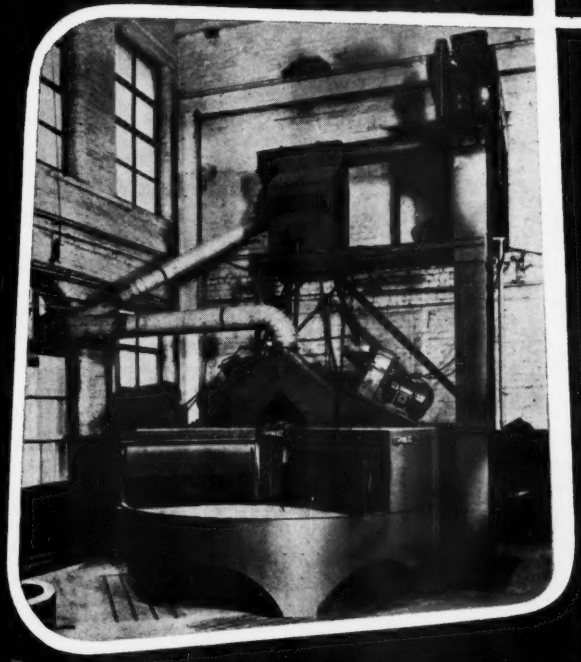

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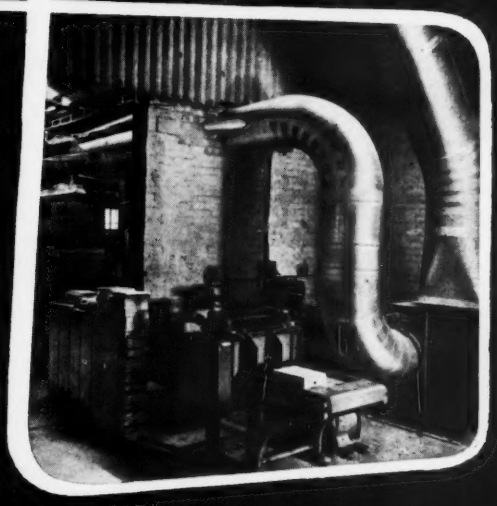

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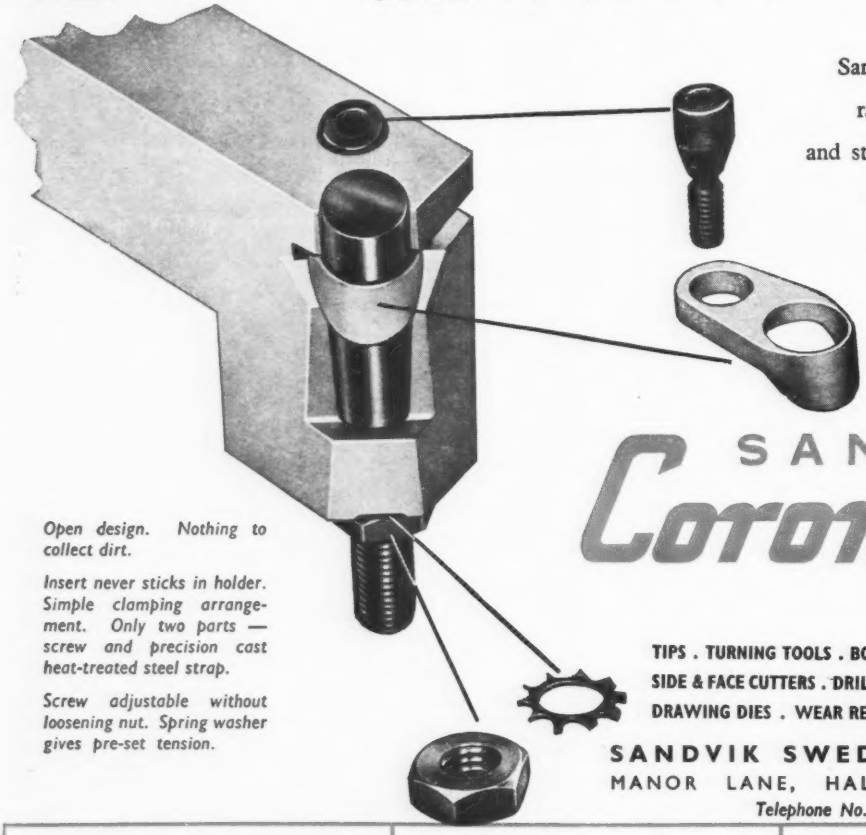

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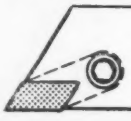
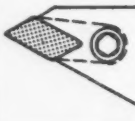
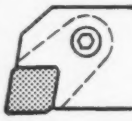
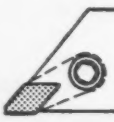
Fischer Copying Lathe Tool 170-1 50°	 Copying Lathe Tool 170-871	Knife Tool 175
 Fischer Copying Lathe Tool 170-1 58°	 Knife Tool 173	Finishing Tool 176
 Copying Lathe Tool 170-870	Roughing Tool 174	Facing Tool 177

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Stock dia.	1 7/16"
Spindle r.p.m.	764
Cutting ft. per min.	287
Time per part	28 secs.
Hour prod. gross	128

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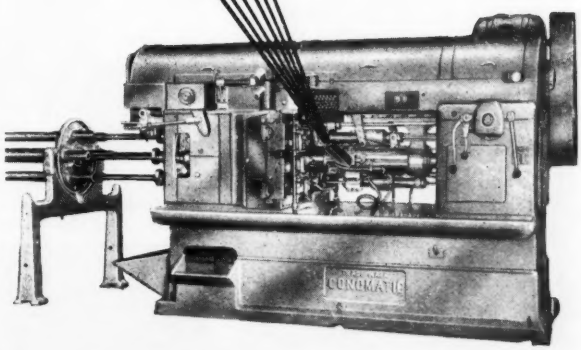

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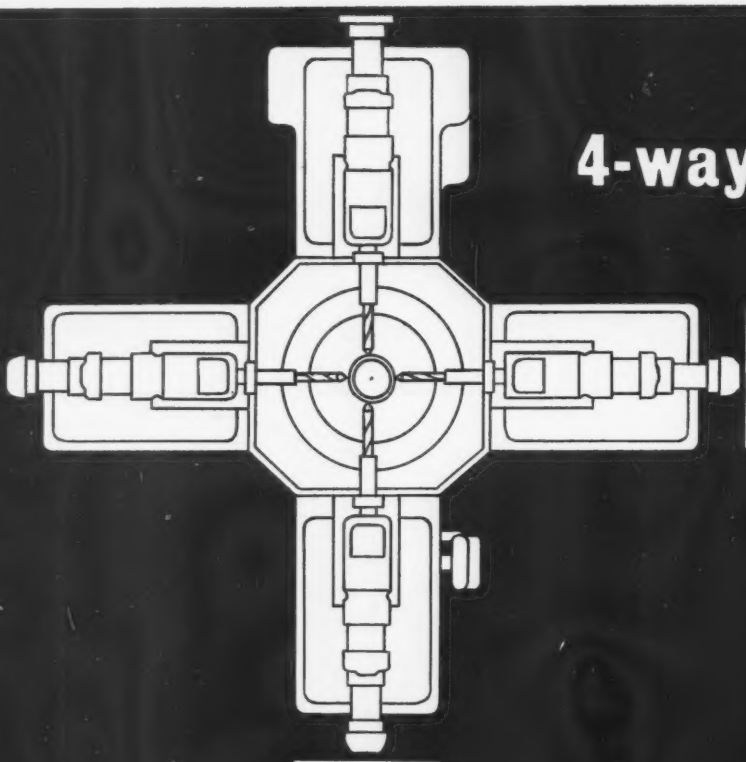

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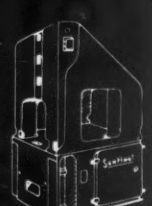
4-way Centre Table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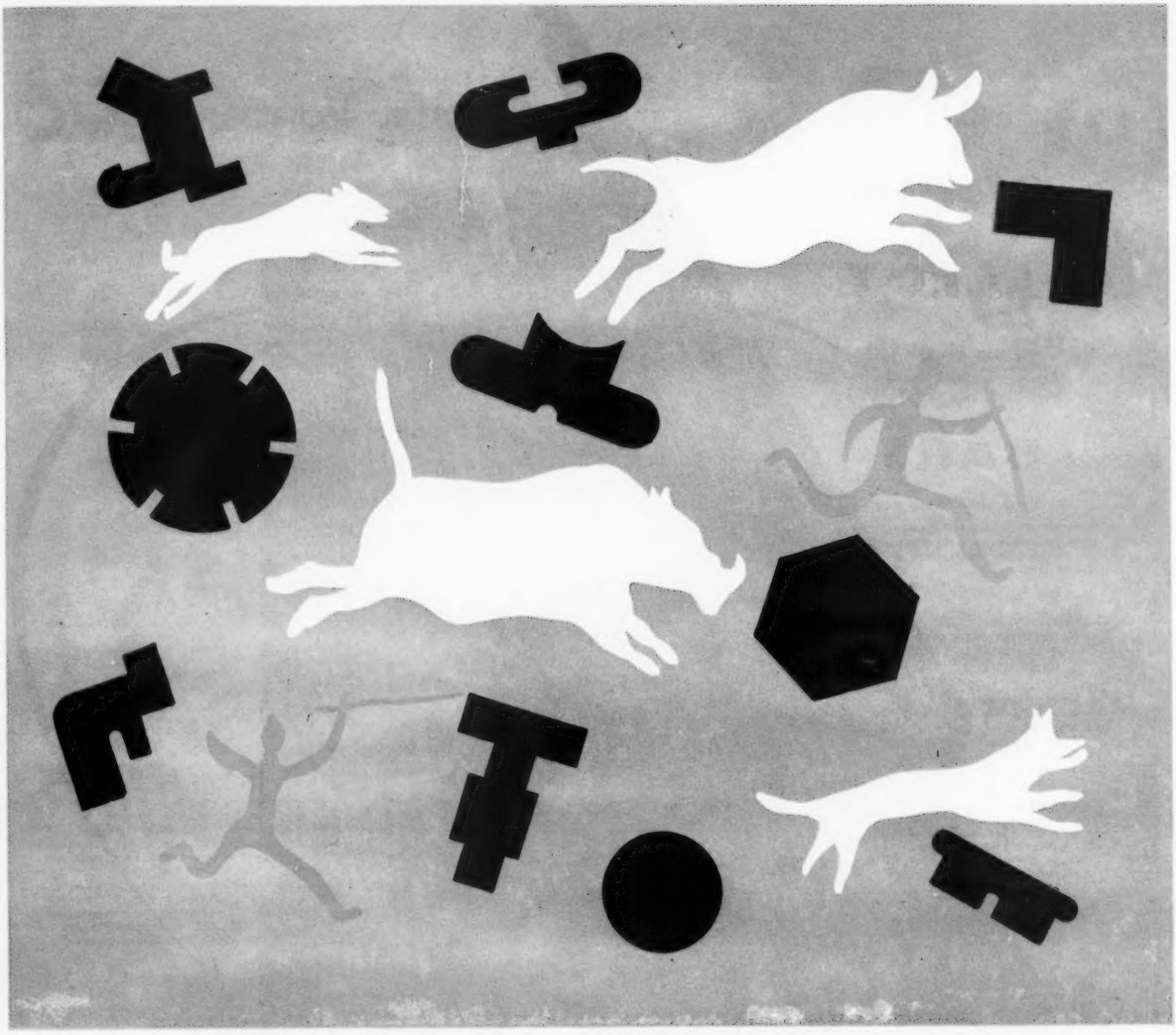

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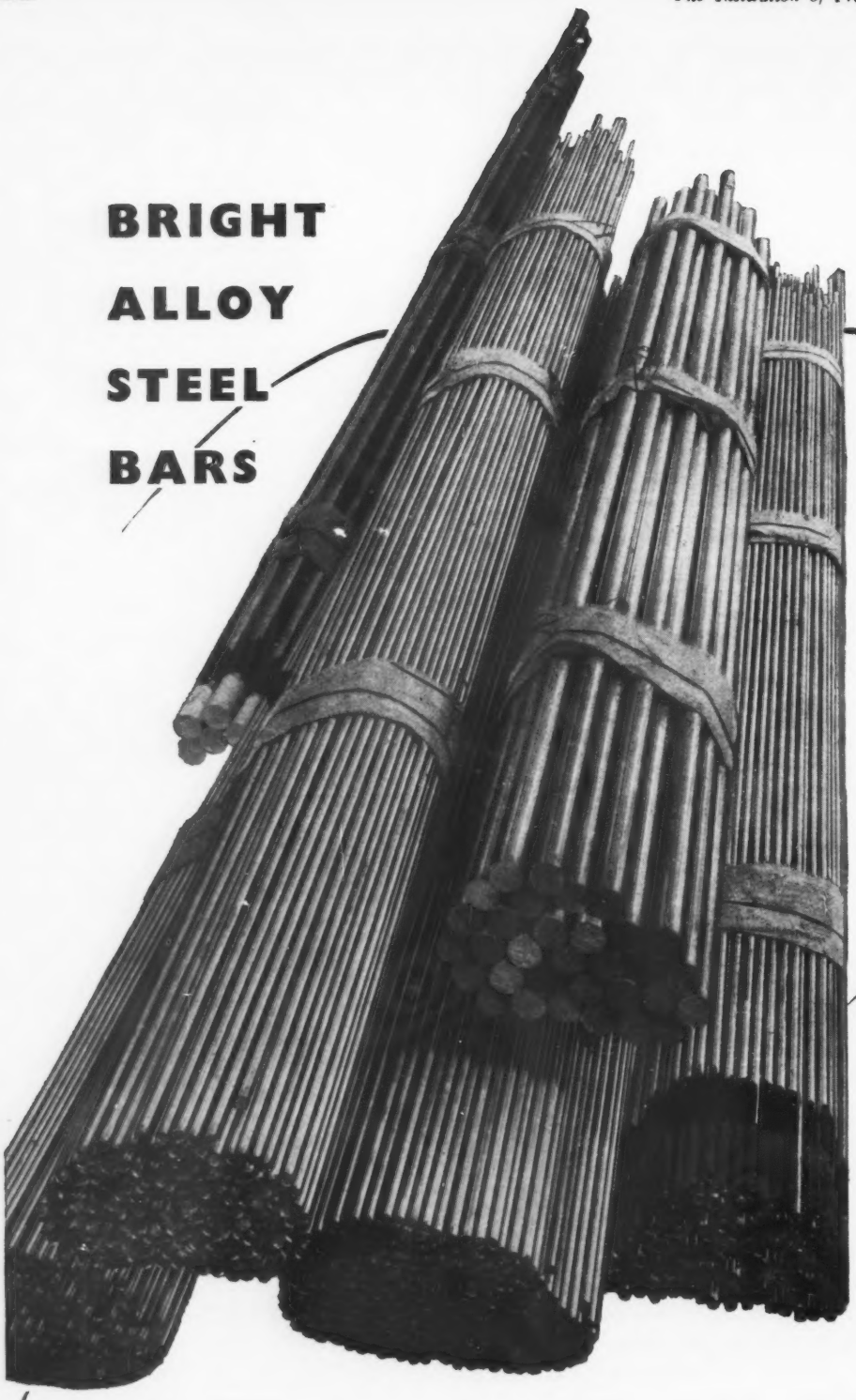

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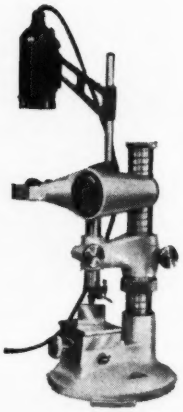

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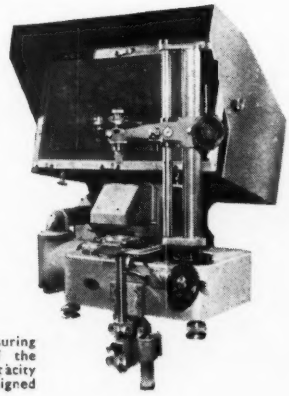

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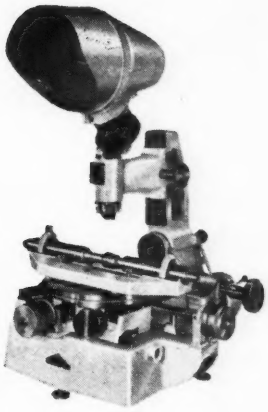

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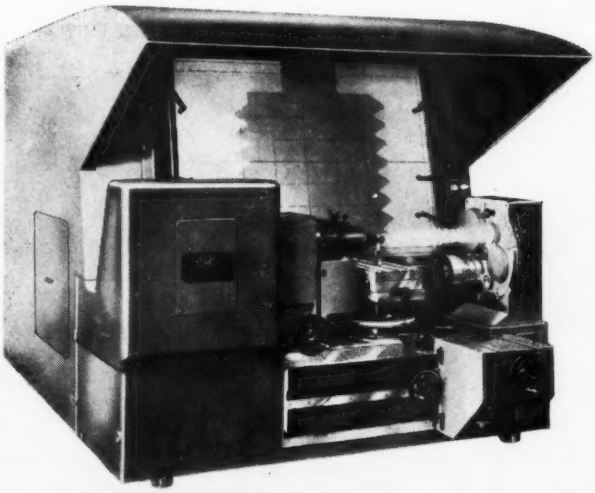

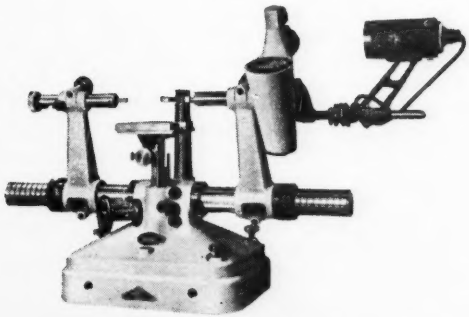

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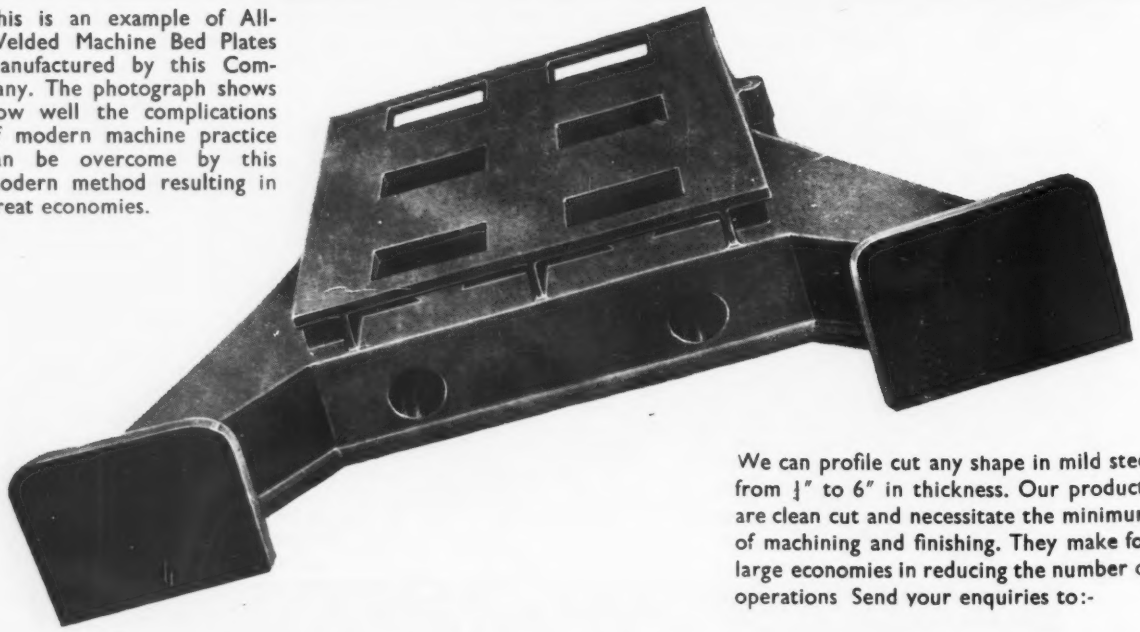

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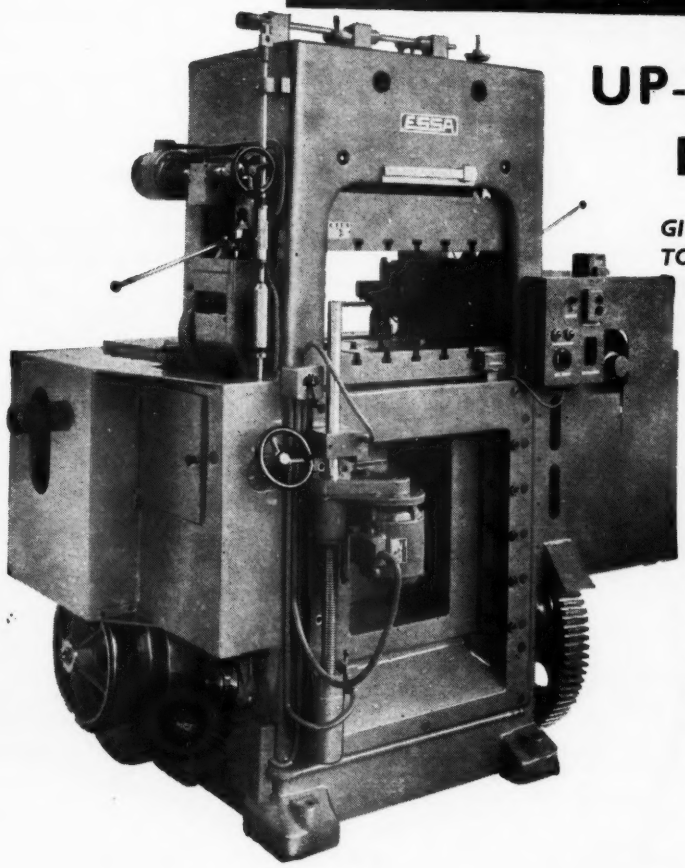

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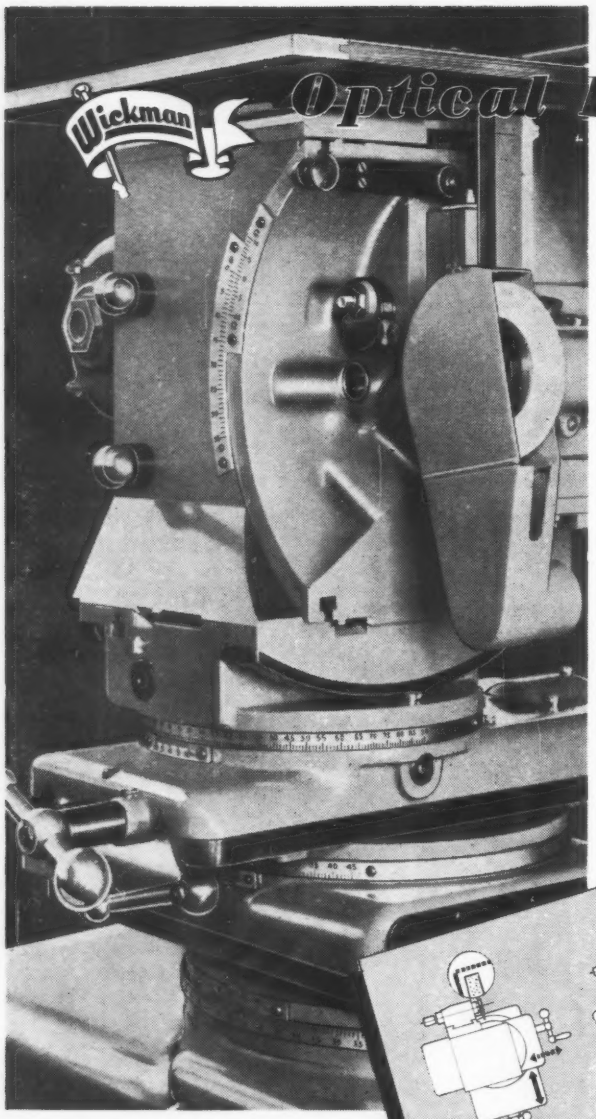
Optical Profile Grinding

Traverse-ground angles simplify form production

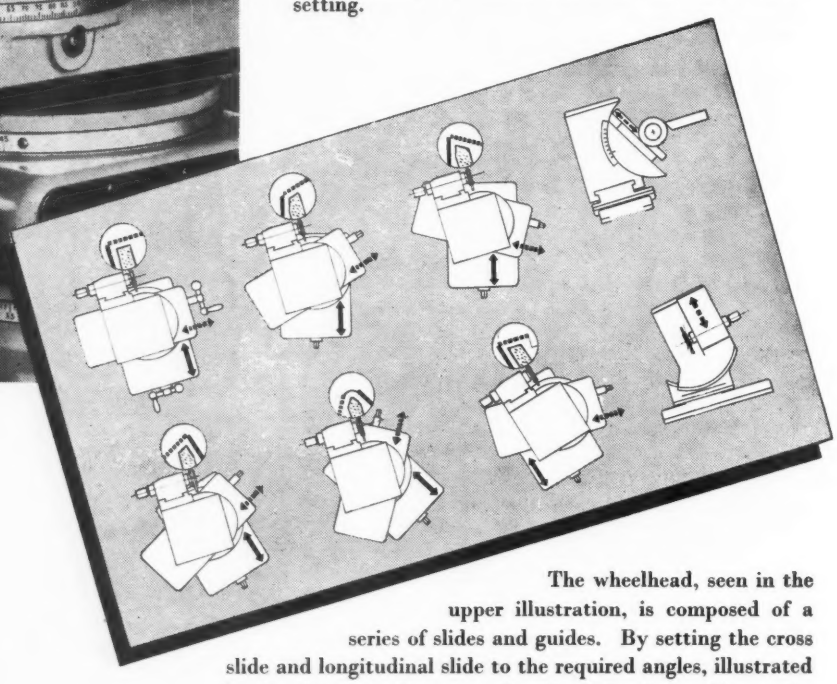
Although the principle of operation on this machine is based on a pantograph controlled optical system for the production of irregular contours, when the required profile includes angular forms, these can be more simply produced by utilising the multiple slide arrangement of the wheelhead (see sketches).

This is composed of a series of slides and guides and by setting the cross slide and longitudinal slide to the angles required angular forms can be ground by traversing, using the pantograph and microscope at the end of the angle for checking purposes.

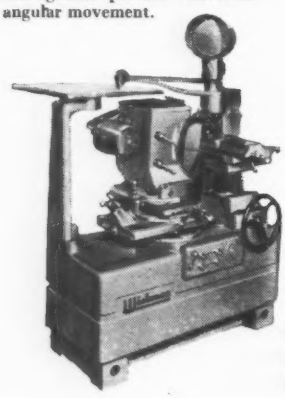
Clearance angles can also be ground as part of this forming operation without affecting work setting.



The wheelhead. Multiple slides and guides provide universal angular movement.



The wheelhead, seen in the upper illustration, is composed of a series of slides and guides. By setting the cross slide and longitudinal slide to the required angles, illustrated in the sketches above, regular forms in the profile can be ground by direct traverse, using the pantograph and microscope only at the end of the angle for checking purposes.



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Depth of Form	2¼″
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The Institution of Production Engineers Journal
VOL. 37 No. 2 FEBRUARY, 1958

Operation Future - the engineer in a changing world

by **Walter Scott**

Governing Director,

W. D. Scott & Company

Pty. Ltd., North Sydney,

New South Wales.

presented to the

Melbourne Section of

the Institution on

25th September, 1957,

as the second annual

James N. Kirby Paper.

MY pleasure at the privilege of being asked to address you is accentuated, amongst others, by three factors. In the first place, it gives me great pleasure to be addressing the members of The Institution of Production Engineers. I know something of your Institution here and know it reasonably well in the United Kingdom, and in both countries. I am well aware of the splendid work which you have been doing.

I want to pay tribute to the quality of the literature produced by your Institution in England. Some of the reports of proceedings in technological fields which have come from your Institution will undoubtedly bear comparison with anything that has been published in any part of the world.

The second reason is that this Paper was last year the subject of a splendid contribution by Mr. Norgard. I have read his Paper and my only hope is that what I have to offer you tonight will be adequate to preserve the splendid example and standard that he set last year.

The third factor which I want particularly to mention is that I feel privileged in giving the J. N. Kirby Paper. There are few industrialists in this country who have made a greater contribution to the industrial progress of Australia than has J. N. Kirby, and I am delighted indeed that my name tonight is associated with this lecture which bears his name. As you will see, so many of the things which I shall mention tonight have been splendidly exemplified in the example of J. N. Kirby.

We live in an exciting and a challenging world. The last 50 years have seen some startling changes in many spheres of human experience. Those that have lived 50 years, for example, have experienced

two major world wars. They have lived through an epidemic commonly suggested as being the greatest in history. They have been beset by the greatest depression in history — that soul-searing experience which we hope will never be repeated. Then, since the close of World War II, they have lived through a cold war period unparalleled in history, with the possible exception of the last two or three years prior to the outbreak of World War II.

assessing the situation

Let us examine these changes in three interwoven spheres and see whether we can thereby assess the present situation and attempt perhaps to peer into the future.

First of all — the political sphere. During these last 50 years, the map of the world has been redrawn. Many of us here will remember, as children, looking at maps of the world in which a striking portion was marked in red — denoting the British Empire. Today its title is changed — it is the British Commonwealth of Nations. Many of the countries previously marked in red are now largely independent and the balance of power has changed. The map of Europe, too, has long lost the Austro-Hungarian Empire, and France, Germany, the Soviet Satellites and the Balkans bear little resemblance to the state existing during the first decade of this century. We have seen a Germany beaten twice, come back with a resurging effort. We have seen the mantle of leadership thrust somewhat rudely upon the shoulders of the United States; and, particularly in this post-war period, we have seen the rise of an implacable Russia and the first stirrings of a Chinese giant. We have seen a demilitarised Japan possessed by a conquering people and the rise of a Middle East, with striking strategic importance.

There is, too, a political ideological set-up virtually without precedent, for we are witnessing virtually the whole of the world, with the exception of an unimportant fringe area of no-man's land, divided into two political camps.

Yes — how different is the political map today as against that of 50 years ago.

To many listening to me, however, the changes in the last 50 years have even greater significance when translated into the technological field. It is indeed a far cry from the industrial and technical world of 1900 to that operating today. I do not need to detail these things, but perhaps I could illustrate progress by saying that it is just 50 years ago since the Wright brothers undertook their first flight. Today the wing span of a modern Constellation is greater than that first flight.

At the beginning of the century the world was receiving the fully fledged effects of the Industrial Revolution caused by the meeting of two great forces — steam and electricity. Today, the world awaits with breathless wonder the technological panorama being unfolded by the meeting of four great forces — Automation, Electronics, Atomics and Cybernetics. In order to get all of this into true perspective, let me, in passing, give you four statements :-

> " Ultimate automation based upon atomic power will make our modern industry look as primitive and outdated as the stone-age man looks to us now." ALBERT EINSTEIN

> " Nuclear power could unfold a ' future beyond the present dreams of mankind '." WINSTON CHURCHILL

> " The very fact that electronics and atomics are unfolding simultaneously is a portent of the amazing changes ahead. There is no element of material progress we know today . . . that will not seem, from the vantage point of 1980, a fumbling prelude." DAVID SARNOFF, *Chairman, Radio Corporation of America.*

> " Cybernetics holds within itself not only the seeds of what may well turn out to be a Second Industrial Revolution; perhaps more importantly, it also provides us with the seeds which, when properly cultivated by management, will help us to master this revolution and convert its hostile potentialities to friendly usefulness." PROFESSOR ALEX. RATHE, *New York University.*

We hear a great deal today about both automation and nuclear energy — so much that the opinion of R. J. Cordiner, President of the General Electric Company of U.S.A., is of interest :-

> " When the history of our age is written, I think it will record three profoundly important technological developments :
>
> " Nuclear energy, which tremendously increases the amount of energy available to do the world's work;
>
> " Automation, which greatly increases man's ability to use tools; and Computers, which multiply man's ability to do mental work.
>
> " Some of our engineers believe that of these three, the computer will bring the greatest benefit to man."

the speed of change

Before we leave this matter, it is of importance not only to note the *extent* of technological change, but also its *accelerating speed.* Have you tried to make a list of things now almost fundamentally important to human life that were unknown when World War II started ? Go wherever you will — to the factory, to the office, to distribution, to transport, to agriculture, and you will find that technology is changing the conceptions we had of these things even a few short years ago. We are constantly witnessing the effect of technology, not only upon our material resources,

but also upon our psychological attitudes — the way we look at research, at social conditions, at management, at education.

Today, technology rules our every movement, and this is likely to be more so in the future. Professor Erwin Schell, whilst in Australia, said that the President of the du Pont Company in America, after pointing out that 50% of their present saleable products were unknown to them 10 years ago, went on to say that they expected that 90% of their sales in 10 years' time would be in products of which they have no knowledge at the present time. Thus does technology expand and accelerate and provides its own evidence of the second great change of this century.

what of the future ?

And what of the future ? Simply that it is universally accepted that we shall find that the pace of technological development ever increases demanding more capital, more education, more skill and more understanding.

When the history of our time can be judged, it is likely that the march of economic events, which does not at the moment appear to be so revolutionary, will take at least equal place with, and perhaps take pride of place to, the other two momentous movements of the last 50 years. It is beyond doubt that the changes in the political and the technological fields are, or are commencing to manifest themselves in ways as great and with implications equally strong and important as in the other two fields.

We can pass over quickly the decline in British economic strength from the halcyon Empire days at the beginning of the century through economic hammer blows of a World War, a world depression and another World War. Nor need we spend much time upon the weakening of imperial preferences, the efforts of the World Trade Organisations and the economic effects of the United Nations. Rather can we concentrate upon other matters of even greater significance.

The political rise to leadership on the part of the United States has been accompanied by an economic growth unparalled in the world's history. The necessity to harness every aspect of production for the winning of a cruel, relentless war, meant that productivity increased by leaps and bounds, and the means of production, freed from war needs or at least partly so, produced a standard of living which is the envy of the world.

In this post-war period, the aspect of economic aid has been one of the most important in economic history. The U.S.A., faced with the necessity of rehabilitating a war-torn world, launched an unparalleled example of generosity in the Marshall aid schemes and subsequent aid programmes in an attempt to win the world back to normalcy. It did not, however, when it first started to realise the implications of the rise of Russian nationalism, foresee that before too long its own generous programmes would be matched and perhaps exceeded by the economic aims of a country — Russia — that began to recognise that whatever country dominated the world in an economic sense, was apt to dominate it politically. History bears constant witness to this fact. This was extremely important thinking in a world stalemated politically by the hydrogen bomb and so the stage was set for economic rivalry of the fiercest ideological kind. The aid programme of the U.S. was matched or bettered by that of the Soviet Union. The relationship between the Soviet Union

★

The James N. Kirby Paper was founded by the Institution of Production Engineers in recognition of the services to the Institution and to Australian industry of James N. Kirby, C.B.E., M.I.Prod.E., Past President of the Institution in Australia.

Mr. Walter Scott was invited to present the 1957 *Paper before the Melbourne Section on* 25*th September,* 1957.

Mr. Scott is Governing Director of W. D. Scott & Co. Pty. Ltd., management consultants, Australia, with branches in New Zealand, South Africa and U.S.A. Mr. Scott is also on the boards of several public companies. During World War II he was Deputy Chairman of the N.S.W. Board of Area Management of the Ministry of Munitions. Subsequently he was a member of the Secondary Industries Commission and several other commissions and committees set up by State and Federal Governments. He is the senior Vice-President of the International Committee for Scientific Management, which has approximately 30 *nations as members.*

In 1957 *Mr. Scott received the Wallace Clark Award for "distinguished contribution to scientific management in the international field", awarded by a committee representing the American Society of Mechanical Engineers, American Management Association, U.S. Association of Consulting Management Engineers, and U.S. Society for the Advancement of Management. Mr. Scott has written several books, including "Australia and the Challenge of Change", and "Greater Production — its Problems and Possibilities".*

and China was fostered to the greatest degree. Russia began using her undoubted advantages as a totalitarian nation in order to win economic battles. It could manipulate its exchanges to suit itself. It could put on a buying programme or withdraw from one at any time that seemed to give it an advantage. It was able, because of its lower standards of living, to take produce in exchange for its heavy machinery and thus make a real and significant contribution to the economy of the country. It was able to do so many things to much better or much greater degree than could the Western countries. It had no shareholders before whom results must be placed. It need account to no one for its losses.

This, surely, is the explanation for the tremendous economic competition being waged by the Soviet Union. How else can one explain why Russian economic aid is today greater than that of the United States ? How else can one explain the economic trade offers given to the newly-developing countries, anxious above all things to improve in the shortest possible time their much-too-low standards of living ?

It was, therefore, evident to most of the countries in Europe that the rising tide of economic might of the Soviet Union could be such as to engulf them as time went by. From the Russian standpoint, a Europe largely under her domination, allied to the might of the Soviet Union, would represent a power far greater than that of America.

It was probably this factor more than any other which prompted the thinking, the early thinking, about the European common market. It is only in these terms that the development of such a market can be understood. The countries which could not stand up against the Soviet Union individually knew that their one chance was to form a union and thus present a united front. So we have Germany, France, Italy and the Benelux countries forming the European Common Market. Now what is the effect of this ? It means that these countries between them have a combined population of 161,000,000 people and form a very powerful economic bloc.

the European Common Market

If such a movement could be brought to fruition, it represented an opportunity at least to stalemate, if not to checkmate, the Soviet economic plans. The Soviet Union, with a population of some 205,000,000 people, had a great economic opportunity to win the economic battle against Europe when the countries of Europe were divided between themselves. If the European Common Market could be brought about, however, it would mean a combined economic strength which approximated that of the leading economic power in the world — the U.S.

It is interesting to note that the first thoughts about something of this kind can be traced back to the year 1638 by Sully, the famous Minister of Henry IV of France, who called it the "Grand Design". It was revived in modern dress by Monsieur Briand, the French Prime Minister in 1929, but it did not begin to play any part in practical politics until March, 1943, when Sir Winston Churchill outlined his conception of a United Europe which should be created after victory was won.

As the United Kingdom Council of the European Movement wrote just a few months ago :-

> "All of us have learnt from the last War, from the Suez crisis, that no country can stand alone; and that individually the countries of Western Europe are too small to negotiate effectively with either the United States or the U.S.S.R. Also, as individual countries, we are at the mercy of blocs which control our basic resources. Alone we can do so little; together so much."

None of the Western European countries could afford to ignore the solemn warning by M. Spaak, who said :-

> "No one can imagine the number of problems that face the creation of a Common Market, but if we do not create it, Europe will be among the undeveloped regions of the world within three decades."

Why ? Let a former U.S. Secretary of State, Dean Acheson, tell you as he told an American audience just last year :-

> "Today, as the Soviet Union moves forward impressively in industrial power, all of Western Europe and America are required to balance it" — (22nd June, 1956).

There are, however, other countries in Europe anxious to be included in some joint arrangement and yet prevented from doing so by ties which prevent adherence to the rigid terms of the Common Market. The outstanding example is, of course, Britain, which is surrounded by her Imperial preferences and hedged about by her position in agriculture. Britain, therefore, has proposed a European Free Trade area which, if accepted, will also include the Scandinavian countries, Switzerland and Austria, giving a total population of 240,000,000 and, perhaps ultimately, Greece, Iceland, the Irish Republic, Portugal and Turkey, with a total finally of almost 300,000,000.

Either the European Common Market or the Free Trade Area represents units strong enough to stand up to the economic competition of either the United States or Russia and, indeed, strong enough in an economic sense to lead the world. Whilst the European Common Market is an accepted fact, there are many difficulties in the way of a European Free Trade Area. Particularly in Britain's case, the harmonising of present commitments and the demanding requirements of the closest association with Europe, provoke many difficulties, as do also her desires to preserve her own agriculture because of its importance in time of war. The most important fact arising out of this, however, is whether the six European countries comprising the European Common Market will accept the European Free Trade Area, or whether they will force a country like Britain to make the choice between her Commonwealth ties and the undoubtedly tremendous

advantages of being part of a free Europe. For Sweden, Switzerland and Austria, too, it would mean partially abandoning their neutrality, committing themselves to Europe in the teeth of tradition in Switzerland and Russian disapproval in Sweden and Austria. These are, indeed, momentous choices and involve revolutionary changes in thinking.

progress in Russia

The implications of this great economic movement have not been lost upon the two most powerful countries. The Russians have already put up, and are reported to be working on, a counter proposal involving the inclusion of Eastern Europe. That was a very significant statement made to a top line U.S. diplomat in Moscow :-

> "Of course we'll win — we've got the raw materials, the labour and the technical know-how. We don't have strikes or depressions, our production is rising at a faster rate than yours. These last five years alone, industrial growth in the Communist world has been equal to the total industrial production of Great Britain and Italy together" — (25th June, 1956),

Then, just five or six weeks ago, Eric Johnston, whose voice is heard with respect and whose advice and counsel have the ring of authority in U.S.A., told his countrymen that the need for an American Common Market was urgent and imperative. It would mean, incidentally, an economic unit, if it embraced United States, Canada and South America, of some 350,000,000 people. The Common Market, said Johnston, is "an opportunity beckoning the peoples of all the Americans from Canada to Cape Horn". (There is talk of some parts of Africa being included.) The problems are, of course, immensely greater than those of a European Common Market and their implications at least as great. Finally, there has also been vague talk of a Far Eastern Common Market which appears as yet to be little more than imaginative dreaming, and I noticed, as no doubt you noticed, Sir James Fletcher's suggestion of economic integration between Australia and New Zealand.

important counter-moves

The checkmating or, at least, stalemating of Russia's economic plans in Europe highlight the importance of her own political counter-moves in the Middle East, for a Europe greatly affected by a Suez closure could be most seriously and adversely affected by a stoppage of Middle East oil. Indeed, over a prolonged period, a haughty Europe could be almost brought to her knees. Furthermore, the next 50 years could bring the greatest changes in the world emanating from Asia. A resurgent China, wakening from its long sleep, an India, struggling desperately to feed its people and to lift its standards of living, and endeavouring to do this competitively with the progress being made in China, offer opportunities for the greatest speculation. The Russian and the European human resources look comparatively puny against the thousand millions of Asia who are waiting for capital, for industrial power and for opportunity to throw off the economic shackles that have held them for so long.

I hope you will forgive me for spending these few minutes on this picture. I do so with only this justification in mind — that we cannot look to the future of Australia and the part that we should play in it unless we can have an appreciation of some of these things which are happening in the rest of the world. Today, more than ever before, is the concept of Wendell Wilkie's "One World" more realistic and factual, and we cannot but be impressed with that very wise statement of the Begum of Pakistan when she said that when the world was big we could afford to think small, but now that the world is small, we must think big.

the danger of self-satisfaction

It is so easy for us to be satisfied — to be self-satisfied. Yet we cannot remain complacent in the face of what others are doing. We may think things are going well, but if there is any fixing to do, let us remember that the time to fix the roof is when the sun is shining. As we proceed, therefore, decide for yourselves whether the roof requires any fixing.

It is, of course, very difficult to say just where these things will end or even to say just what the next decade will bring by way of actual accomplishment. Two things I think concern us here and now. The first is, how does our country (Australia) fit into this picture; the second is, how do we ourselves fit into and, finally, what part should we play in it ? Looking first to our country, there are a number of matters we must bear in mind.

The first is that, in many a sense, we are a small country. We are small in population, we are small in political importance, we are small in economic maturity. In some ways, but not in all, we are small in strategic importance. Some of these things are natural. The smallness of our population speaks for itself, and the sparsity of its spread in our own country is undeniable. With a few great exceptions, we are not of great importance to the rest of the world. Yet we have a standard of living almost unexcelled and, above all, we have that priceless asset, freedom, that can perhaps be matched but not exceeded anywhere else. Let us not delude ourselves, however; as a small country we cannot always have the economic control over our own actions that we would like. We shall increasingly in the future no doubt be forced, for the sake of some political or economic motive of world importance, to adopt measures which merely offer the lesser of two sets of disadvantages.

Furthermore, it is difficult to see at present just where our own country fits into the economic moves of the projected Common Markets. A Far East Common Market would be impossible for us; the European and American, geographically far removed.

If we were merely bystanders, we could watch the developments of the next few years with unaffected interest. But rather we shall be vitally interested in seeing whether we shall be starved of overseas capital, because the requirements of Europe will tend to use so much European capital as well as American capital anxious to participate on the spot in the advantages the European Common Market can give. Nor must we overlook the possible drain on American resources as the result of any concrete approach to an American Common Market.

the essentials for progress

Despite this picture, it could well be that there *may* flow to Australia, as one of the few countries in the world outside of all these entanglements, the capital which will be so badly required there. *In the meantime, history has repeatedly shown that a country bold in its outlook, determined in its objectives, clear in its thinking, buttressed by stout hearts and very good natural resources, can ensure for itself progress that can win the respect of the world. It is essential that we keep this constantly in mind.*

I would not have you think that because I have outlined the problems associated with economic changes of our times, I feel that we are overburdened with problems and that I, for one, am pessimistic about the future. But we must remember that we must *earn* our standard of living *and keep on earning it*. We cannot expect to have it given to us. Indeed we can so easily lose it by default.

The second thing that we must remember is that the things that must be done can be done only through the resources of our own country — of which by far the greatest is our own people, and as inevitably happens in these cases, some sections of the community must assume a much greater responsibility than others. I strongly suggest to you that most of you listening to me tonight are to be found in one of the three or four sections of the community upon whom this responsibility will most heavily and rightfully rest. Most of you are engineers, though because the dividing lines are indistinct, some of you may think of yourselves as scientists and many of vou as managers. Together with the educationalist, it is upon the shoulders of you people that the future of Australia so largely rests — upon the engineer, the scientist, the manager and the educationalist. Let us have a look at the reasons behind this statement.

a technological world

Firstly, today's world is a technological world and tomorrow's world will almost certainly be even more so. It is largely the world of the scientist and the engineer. Indeed, some eminent authorities overseas have suggested that more and more of the managers of the future will come from the ranks of the engineers. In any case, it is you people. It is you people who will decide the speed and the extent of technological progress in this country. It is you people who will determine whether we keep up with the rest of the world in our technological thinking and whether this country is introduced to the improvements that advancing technology can bring. *In a technological world, Australia must almost certainly look to its technologists*, and Australia must for its part be prepared and determined to pay its engineers.

The second factor to which I want to draw attention is that the political, technological and economic revolutions, *in their final analysis*, depend upon one factor — production. You can examine the free enterprise system of the United States, the semi-socialism of the Scandinavian countries, or the totalitarian regime of the Soviet Union, and you will find that each of them rests on the same cornerstone — production — and that, my friends, comes right back to you, for, primarily, I am addressing a gathering brought together by The Institution of Production Engineers. You are the mainspring from which production flows. You are the people upon whom rests the responsibility for production; you are the people whose very work signifies the beginning of progress. Production and progress have a common beginning, even in their first three letters.

progress, production, productivity

The third *aspect* which I wish to mention is that there is something else which shares that three-letter combination with progress and production — that is, productivity. Indeed, it is so bound up with the other two as to form part of them. The difference between the United States and China or India cannot be explained in terms of population. It is in what the population does that the secret is found. It is the productivity of the people, not only the people themselves, which determines not only the power that rests in a country, but its very standard of living. And who, may I ask, is more responsible for productivity than the engineer ? In company with the scientist and the manager, yours is a role of increasing productivity, because by that means the resources of the country are more efficiently used.

The fourth factor is that this is a young and developing country, and the young and developing countries are particularly dependent upon three all-important factors—the provision of industrial power, the provision of capital and the provision of technological knowledge. Would any one of you dispute the fact that the first and third of these, at all events, are the realm of the engineer ? How could they be produced, how could they be used without the knowledge, the ability and the outlook of the engineer ? The development of a young country is largely the development of its engineering know-how and its engineering resources.

Nor should it be assumed that the aspect of capital cannot be traced to the engineer. I will deal with this shortly but, in the meantime, let me point out that there would be many good judges intent upon defending the proposition that capital flows (as does authority) to the one who knows.

Yes, my friends, there is a tremendous responsibility for his country's development upon the engineer. As Lee Dubridge, President of the California Institute of Technology, put it :-

> " Yes, in 50 years we have gone from wagons and kerosene lamps to airplanes and television. And whence come all these changes ? Did anyone in Washington invent the electric light ? Did the accounting department invent radar or television? Did the political actions of Theodore Roosevelt or Woodrow Wilson create the radio industry or the oil industry ? "

Let me, therefore, bring the world situation right back not only into terms of Australia, but into terms of this hall, with you people as the engineers who must do things. But you may say to me, and with great justice, " this sounds all very well, but I am merely one engineer and what can I do in a situation of this kind ? ". Let me, my friends, try to bring this picture right down to you individually and try to leave with you something of the obligation that rests with you. Whilst there are others, I will direct my attention to three all-important obligations which rest squarely on *your* shoulders.

Firstly, there is a technological obligation. Maybe you are simply one engineer amongst many in a large organisation. Maybe you are a single engineer working in a small organisation. I suggest to you that makes no difference, because the things which have to be done in this country can only be done as the result of everyone bearing some part of the responsibility — or, as we so often put it, everyone pulling his weight. Yet you may still say to me, " that sounds fine, but it still does not show me what my personal part in all this really is ". Well, let us have a look at that, and see whether we can justly answer it.

I have already indicated that production and productivity are so largely the province of the engineer. Therefore, there is an obligation upon you as a single engineer to make sure that you, as part of the organisation for which you work, constantly keep your productivity obligation in mind. If you are a single engineer in an organisation, you are perhaps solely responsible. But the position is the same in both cases. The right type of thinking about production and productivity should flow down from you — you should never expect it to seep up from the men under you. In order to do this job of production and productivity properly and in the way I am sure you would like to do it, in the way your organisation would like to see it done, and in the way that would be of most benefit to your country, there are two further obligations upon you. In a rapidly-changing technological world, it is your job to be, and to keep, technologically up-to-date. In the first place, in competition, it can mean the difference between success and failure, but apart from that, keeping up-to-date in the world of today is like an exciting adventure where each turn of the road can bring a vista almost unimagined. In a world dominated by automation, electronics, cybernetics and atomics, there can be an exhilarating challenge — but there can also be concrete progress in your own job. No — there can also be the question of survival, your business survival in a changing world. No less a person than the late John Von Neumann said just before he died :-

> " The technology that is now developing and that will dominate the next decades, seems to be in total conflict with traditional and in the main momentarily still valid geographical and political units and concepts. This is the maturing crisis of technology."

Not without reason did Phil Carroll, a production engineer, say :-

> " Don Copell puts it this way : ' Remember that no war, no strike, no depression, can so completely and irrevocably destroy an established business as new and better methods in the hands of an enlightened competitor. Remember also that engineers are working nights, Sundays and holidays to make obsolete your products, your equipment and your methods. These men are in the design departments of your competitors, your suppliers, and your equipment builders. Consulting engineers are helping them get ahead of you.' Gerald Wollam says : ' Don't try to compete today using yesterday's method if you expect to be in business tomorrow."

It is quite obvious that this can have a very personal importance for you, but it also has a national importance. Back in 1934, a group of 27 engineers working for the U.S. Columbia University Commission on Economic Construction, estimated that the output of all industries in the United States could be increased 75% " with equipment and management brought to the level of best current practice ".

four important factors

There are four important factors in this statement. The first is that the figure mentioned is 75%, a startling figure. The second is that the estimate was made in relation to America, where methods are generally acknowledged to be ahead of this country. The third is that the statement was made by an independent Commission from Columbia University. The fourth factor is that the year in which the statement was made (1934) was just after the full blast of the depression had been felt in U.S.A., and consequently it is not unreasonable to assume that management, faced with heavy depression losses, would have explored better methods in order to reduce them, and indeed pursued every efficiency in order to reduce the losses that were a commonplace during the depression years.

Think of it — an increase of 75%. Let us say even 50%. At our present rate of productivity increase, this represents a gain in time of the best part of 15 years. Is that important ? Is that making sure of survival ? Is that fulfilling a national obligation ?

Of course it is! Maybe you cannot increase it by 75% in your place but 5%, 10%, 15% may make a tremendous difference to your own organisation and to this country. Do I hear you say that is a hard assignment ? Maybe it is — most good things worth doing in life never come easily — but remember others may be doing these things and your choice in these things may later change into compulsion. You can commence increasing productivity in your organisation tomorrow at 8 o'clock. There is always something which can be done.

But this technological obligation that devolves upon you goes far beyond even the obligation of production and the responsibility for productivity. It overflows into so many other fields. Let me briefly recount two of them. A friend of mine with a world-wide reputation, Harold B. Maynard, speaking recently before the Engineers' Club of New York, said :-

> " Within 10 years, 75% of all important management decisions by major American companies will be the result of mathematical computations."

There are two significant factors about this statement. The first is that it was said to the Engineers' Club, and the second is that the training of the engineer is eminently suited to assess, if not to develop, all the things which flow from the new mathematical aids and treatments. One of the tools which is developing very quickly is Operational Research. Here is something designed to reduce executive uncertainty in the making of engineering and managerial decisions. Not only does an Operational Research team depend greatly upon the engineer, but it will increase the part which the engineer will play as an adviser to management. We are going to see tremendous developments in some of these things.

widening horizons

I suggest, therefore, that whilst many of you will (or have already) undertaken managerial functions and responsibilities, even where you remain in engineering, the horizon of the engineer and the consequent responsibilities are being ever widened. As engineers, the obligation is upon you to live up to these responsibilities but I, for one, believe that if you do so, the rewards will be commensurate — both financially and psychologically.

Let us come down to a specific question. That this country suffers from a shortage of population and of capital, is undisputed. Have you ever considered how much wasted labour there is through inadequate Quality Control, and how much our capital position could be improved if we could raise the standards of our quality ? One of our recent visitors from U.S.A., Professor Juran, of New York University, and an expert in Quality Control, recently calculated as the result of a sampling procedure amongst some 40 to 50 organisations in Australia, just what this country was losing as the result of poor quality. His figure for defective work was about £200,000,000 per year and, of this, he considered at least £100,000,000 could be saved. Now bear in mind that the £200,000,000 was the result of an enquiry into the position and the results disclosed by a number of representative firms in various industries. The £100,000,000 — that is, about 50% of the £200,000,000 — was arrived at from the results actually being achieved by individual concerns in another country — Japan. Professor Juran had recently spent some considerable time in Japan analysing quality factors in that country. The quality revolution in Japan is largely the result of a determined national effort (which, after all, comes back to the total of individual efforts) to force the world to acknowledge that Japanese goods could hold their own with the rest of the quality-conscious world.

The results being achieved by Japan in this field are an object lesson to every one of us, whether we like it or not. Even top-line German industrialists told me a mere two months ago, that the Japanese photographic equipment was at least as good and often better than their own.

harmful production

Waste and defective goods benefit nobody and harm all. They are thieves of industrial effort, of materials and resources, and they steal capital. With 10% of defective work, you are employing 10% of your capital, of your machines, to produce goods which often are valueless and usually are economically unattractive.

But there is another lesson in this. I do not know, but I feel quite certain that the Japanese national drive on the improvement of quality emanated from the engineer and the manager. This is merely one more of the innumerable opportunities waiting for *you* to grasp.

My first challenge to you, therefore, is this – in a technological world, Australia looks to you to keep it up-to-date, to show it how to increase its technological resources, how to use its progress at a time when the very nature, speed and extent of such progress is well nigh bewildering. These things make you largely responsible for accelerated progress in production and productivity and for at least preservation, if not the raising, of a standard of living already the envy of most of the world at large. They make you responsible, too, for changing the habits of industry in a number of fields nationally vital, of which the improvement of quality is but one. Not without cause did the President of General Electric Company recently say :-

> " All these fields are so promising that we expect to produce more in the next 10 years than in all the previous 75 years of our existence."

So, my first question to you tonight is : What are you as an Institution, and as individuals, going to do about productivity ?

Now let me turn to the second major field of obligation upon the engineer — education.

technical education

We have heard a lot about technical education in the past year or so. To a certain extent, this has been engendered as a result of a realisation by the Western world that she has been out-manoeuvred by Russia in the training of technical people — the engineer and the scientist and also the technician. I will not weary you with the figures. They are available elsewhere. What does arise in clear and unmistakable fashion from the evidence, however, is firstly, the fundamental importance of the training of technologists; and, secondly, that progress in a technological world is dependent upon the numbers of adequately trained engineers and scientists. No wonder that Kruschev, in his visit to India, placed such extraordinary importance upon this factor. "We shall see", he said, "who has the more scientists and engineers — the United States or Soviet Russia." Why did he say this ? Because he knew it was synonymous with saying: "We shall see who will make more progress in this essentially technological world, the United States or Soviet Russia".

It is accepted that we in this country are seriously lagging, but whilst there is much talk, little is done. In company with others, surely here is a project worthy of your steel. If you are sure of the importance of the engineer in the community, if you are certain that Australia's progress and development cannot be considered without thinking in engineering terms, then I suggest to you seriously that one of your most solemn obligations is to ensure adequate continuity in engineering skill. In fact, you must make sure not only of continuity in engineers, but also of amplification of engineering knowledge and engineering power.

We want more engineers. You are engineers. How do we get more people into engineering ? What are *you* going to do about it ? What is this Institution going to do about it ? And even if you feel that you have played your part in the past, it is, I think, fair comment to say that the past is not good enough, that we must certainly get greater results in he future then we have been able to get in the past.

General Electric in U.S.A., incidentally, expect to produce more in the next 10 years than in the previous 75 years of its existence. No wonder *it* is spending 43 million dollars in one year *training people*. No wonder the U.S. Chamber of Commerce is advocating that business should spend 5% of its net profits on *education*.

I hope you will make your voice so powerful in your own Institution and the voice of your own Institution so powerful *in this country*, that the voice of the generation to come will not be blaming you for your part in one of the gravest derelictions of duty for, mark this well, not only will we not know what sort of a job we have done in education now until the next 10 to 15 years have passed, but also it will be the coming generations that will benefit or suffer by the job we are doing now. At that time — in 10 to 15 years — it will be too late to alter it. Don't let the tag of "too little, too late" ever be said in relation to your part in engineering education. What a challenge to you all! And how much there is to be done! Don't we want Universities of Technology Industrial Engineering ? Can't we do something about wastage of talent and such essentials ?

But the problem goes even further than this. Every engineer should be able to spread his knowledge and his supervision amongst five to six technicians. What are we all going to do here ? Let us take just one, but an all-important section, of this field.

Those of you who have been overseas know well — only too well — how exceedingly badly we are measuring up to our responsibility in the apprenticeship field. When one sees what is being done in training apprentices in, for example, Germany and France, one is appalled at our own neglect. In Germany, for example, in 1954, 900,000 boys and girls left school and, of these :-

495,000 entered as apprentices;
45,000 entered as trainees;
225,000 were not in organised training; and
135,000 proceeded to higher education (full-time).

At that time, the following contracts of apprenticeship were lodged :-

with the Chambers of Industry and Commerce	670,000
with the Chamber of Handicrafts ...	560,000
	1,230,000

Impressive numbers ? Yes, very, but one has to see the training these apprentices get in order to appreciate the gulf between what they are doing and what we are doing. The most significant factor of all, however, is that the great majority finish their apprenticeship, and because of the thoroughness and the completeness of their training, they are giving to Germany another inescapable necessity in a technological world — technicians.

the production engineer's responsibility

What are you going to do about this problem ? Aren't *you* the people who are most affected, who ought to know more about these things than anyone else ? Upon whom, then, does this responsibility largely rest ? What are you going to do about it ? If you do not take up such an issue as this, maybe it will never be taken up and Australia will be the poorer because of your neglect.

I fancy that I can hear some of you say that that sounds all very well, except that it is a good maxim for someone else to follow, someone else who is in a much better position to do it, someone who has much

more authority, whose standing is greater and whose voice will be more likely to be heeded.

importance of the small firm

Perhaps I hear it said that you are only in a small industry. Let me say something about small industry at this juncture. Small industry is every bit as valuable to a country as large industry. True, this country needs its Broken Hill Pty.'s and its paper mills and its sugar companies, but it also needs its small organisations. We are apt to think of U.S.A. as a country of big business, yet so important is small business in U.S.A., that in the last elections both the Democrats and the Republicans promised that, if elected, they would set about giving increasing help to small business. President Eisenhower set up, some little time ago, a committee to find out what would be the best way to help small business, and the significant factor about that Committee was that its Chairman was the Chairman of the President's Council of Advisers, and four of the members were Cabinet members, including Charles E. Wilson, the Secretary of Defence, but also the man who had headed General Motors Corporation, the Secretary of Commerce, the Secretary of Labour, as well as the Director of Defence Mobilisation. That's what the country of big business, U.S., thinks of small business. That is why belonging to a small business is no alibi for you to use.

influence of the individual

The second thing which I perhaps hear you say is that, after all, you are only one individual, that as one individual there is very little that you can do. Very often it is usually seemingly unimportant things which are of most importance. The leadership of the Labour Party in Queensland was recently lost by a man who lost his constituency by one vote. It is said, for example, that :-

> " Television would be invisible if it were not for 20 cents' worth of luminescent compound that coats the tube and brings the programme to visible life. Twenty-five cents' worth of a fluorinated hydro-carbon charges the average modern electric refrigerator, resulting in safety and reliability. The low pressure automobile tyre of today is made possible by 8 to 10 cents' worth of a chemical and anti-oxidant in each tyre. The transistor depends upon exceptionally pure silicon metal, worth about 10 cents."

So my second question is, what are you going to do as an Institution and as individuals in the field of education ?

If this is not sufficient to convince you that *you* must play your part, let me proceed to the third field with which I want to deal, which comes back to you completely as an individual. It is that of leadership, to which I made a passing reference a short while ago. It is so easy for us in a technological world to think *only* in technological terms. That we must pay the very greatest attention to these is beyond dispute, but no country can succeed if it thinks only in technological terms. In this world of change, everything seems to be pervaded by that very factor — all but one. Despite our improvements, despite our progress, despite our tools and techniques, business and industry still come back to people. In the final analysis, we must deal through people, and people are not only part of our job, but part of our very existence. We can be the most accomplished technologists, we can be the most skilled engineers, we can be the most able originators, but we shall fail unless we find the way of putting these things to work through people. Forty years ago, Frank Gilbreth showed us how to lay 2,800 bricks per day, and we still lay some 400 to 500 bricks. Why ? Because no one has yet shown us how to get people to want to lay 2,800 bricks a day. Where now is our vaunted productivity ? So I say to you that, if you have every other ingredient for success in the things of which I have spoken, but you have not graduated in the faculty of human relations, yours can, at best, be but a partial success. The technologist who ignores this is thinking in the same terms as those employed in originating the great wall of China 2,000 years ago. " Let us ", they said, " build a great wall, which will be impregnable and will for 500 years, because of its strength, keep out the marauders from the north ". And so they built the great wall and technologically it was so great that parts of it stand today — a great triumph of technology to win freedom for 500 years. Yet within 30 years the wall was breached three times. Why ? Because they overlooked the human factor. Three times in 30 years the marauders from the north bribed the gate-keepers and so broke through. A great technological achievement — one of the greatest the world has seen — laid low by the intangible and yet all-powerful weapon of human emotions.

No wonder that Albert Einstein wrote :-

> " It is not enough that you should understand about applied science in order that your work may increase man's blessings. Concern for man himself and his fate must always form the chief interest of all technical endeavours, concern for the great unsolved problems of the organisation of labour and the distribution of goods — in order that creations of our mind shall be a blessing and not a curse to mankind. Never forget this in the midst of your diagrams and equations."

So I say to you tonight that here is a job which must be done individually. You will have to get co-operation from your own individual actions; you will have to promote respect from your workers and the desire to want to do things by your own integrity and by your own leadership. There is no substitute for these things, and this is one of the things where, unlike the field of education, you can do it immensely better individually than ever it could be done collectively.

the indispensable quality

In a technological world, leadership is the one vital indispensable quality. Every engineer should remember that the key to leadership is to be found in the planting in the minds of those under one, the thought that they are working for an organisation which believes in people, respects them, has confidence in their abilities, in their basic integrity and their desire to be a helpful part of the organisation. As Clarence Francis, of General Foods Corporation (U.S.A.), put it :-

> " It has always seemed to me that you can buy a man's time; you can buy a man's physical presence in a given place; you can even buy a measured number of skilled muscular motions per hour or day. But you cannot buy enthusiasm; you cannot buy initiative; you cannot buy loyalty; you cannot buy the devotion of hearts, minds and souls. You have to earn those things."

And that, my friends, is the challenge of leadership before every one of you.

These things seem to me to be the real challenge of the future — the fingerpost pointing the way to the engineer. The things I have mentioned are but examples — the whole catalogue of opportunities embraces many others. Some of these things you can accomplish together. The voice of the engineer is a powerful voice. It is a voice which speaks with authority in these things. It is a voice to which the community at large will listen. But the voice will have to be raised before the community can hear, and act!

Some of these challenges require a concerted action — some can be done only individually. But in them all, it is finally the cause and the call of this country of ours which beckons the engineer onwards to much greater heights in the future than he has attained in the past.

Do not let us sit down under the weight of problems. If there are problems, let us fall in line with Walter Cole, who said last year :-

> " If we are to achieve a victorious standard of living today, we must look for the opportunity in every difficulty instead of being paralysed at the thought of the difficulty in every opportunity."

Where does *your Institution* stand on these matters ? Where do *you* stand ? That is the challenge before you as I see it.

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THE JAMES N. KIRBY AWARD

Mr. Walter Scott (left) receives the James N. Kirby medallion following the presentation of his Paper. Making the award is Mr. W. Gwinnett, President of the Australian Council.

THE MATHEMATICS OF HANDLING

by Dr. K. D. Tocher

A Paper presented at the 1957 Convention, organised by the Materials Handling Group of the Institution, at Leamington Spa.

I SUPPOSE that the question of how mathematics can be used in such a practical subject as handling must have crossed the minds of many of you on hearing the title of the Paper. I must start by stating those applications of mathematics which are not of interest to me.

I am certainly not interested in the mathematics involved in the mechanical construction of handling devices, such as calculating stresses in components or devices which will lift heavy weights, or in the geometric problems of complex linkages.

This is 19th century mathematics, and it has ceased to be of interest to mathematicians. It has now become a useful and everyday and accepted tool of the mechanical engineer.

Nor am I interested in the arithmetic of handling. I am not interested in the actual time it takes to handle any given object. This is properly the subject of work study, and although we shall use work study, it is not our primary interest.

Our primary interest arises from the facts about the arithmetic of handling — the fact that the handling time at any given point in a process will vary from time to time and will vary for reasons that we do not quite understand, do not hope to understand, and — in fact — do not particularly wish to understand.

Our first objective must be to reduce this variability, but we must accept that it is only rare that it can be completely eliminated. The remaining inherent variability of a process such as handling or performing any process is no longer a profitable object of study : it is much more profitable to accept it and once accepted to organise that the evil effects of such fluctuations and variations are minimised.

It is the study of the variations of handling times that exist in a whole handling system and the

repercussions of these variations, and the interactions, and interferences caused by these interactions, that interest mathematicians at the moment.

This interest developed in the first place from the most mundane origin, as a kind of mathematical recreation or game. The things that interest mathematicians are often not of any great practical importance.

The game, in this case, was to try to explain why an Oxford don, whenever he arrived at Paddington Station, could never find a taxi. Whenever he went to Paddington Station and did not want a taxi there was always a very large number of taxis there. There were, he discovered, on careful enquiry, just about enough taxis on an average to meet the demand for taxis. There was a balance in the sense in which we normally think of it, but this balance was rarely achieved in practice. There was either a surplus of taxis or a surplus of people.

Was this just the "cussedness of nature", or was it something that flowed as a consequence from the nature of the problem ?

A mathematical study was made which, with very plausible assumptions about the laws governing the statistical behaviour of people and taxis arriving, precisely predicted the actual conditions. The theory predicts that very rarely indeed would supply and demand be matched.

the Theory of Queues

Out of these very humble origins, the mathematical theory of queues developed, and I hope to show later that this theory can be adapted and modified in such a way as to be very useful in all sorts of industrial applications, and in particular in some of the applications in which you are particularly interested.

I hope that when I have finished describing the mathematical theory of queues you will recognise that it is a descriptive theory. That is to say, it is the sort of theory that says : "If so and so, and so and so, then you will expect such and such to happen". It is a predictive theory. It will tell you what would happen if a particular system of flow of materials with a certain pattern of handling or transit times were to be set up.

Often, the prediction will be rather discouraging. The theory of queues does nothing to show how to change this, beyond saying there is not enough equipment. And it is never a satisfactory solution to increase the amount of equipment or of labour that is used. That is not the typical engineer's way of solving the problem. He tries to solve the problem within the limitation of the equipment he has at the moment.

I do not mean that he refuses to have any other equipment, but his first strategy is to try to rearrange, reorganise or re-employ what he has, so as to give better results without making any capital expenditure.

Thus, the theory of queues is, in itself, not of great value except as a descriptive or predictive weapon. We want a further theory, a theory of the control of situations of that kind.

Such a theory has been developed in other fields, the servo mechanisms, for many years, and one of the things I will discuss here is how the theory of servo mechanisms has been adapted to the extent of controlling process flows and maintaining inventory stocks.

transportation problems

These are two ways in which mathematics can be useful in the handling problem. There is a third and more classical one, the transportation problem : the problem of the most economical arrangement of the forces available for transport of material, in order to move that material from one set of places to another set with the minimum cost.

This has led to a most fascinating new realm of mathematics which at one level of mathematical understanding is simplicity itself. The solution to the problem can be given in one sentence. Yet, as is so often the case with mathematical formulae, it is completely useless to the practical man. It does not provide a practical solution. The fascination is in finding the actual practical solution to a problem given in practical terms. The transportation problem has been expanded into a theory called the theory

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Dr. Tocher, who is Research Applications Manager in the Operational Research and Cybernetics Department of The United Steel Companies Ltd., took an internal London University degree with first-class honours in mathematics, specialising in hydrodynamics, prior to joining a war-time research team specially concerned with aerial torpedoes. After a period with the National Physical Laboratory, he joined Imperial College as a Lecturer in Mathematics. He also took an external London University degree with first-class honours in statistics, and then obtained his Doctorate in the same subject at London.

He has been a part-time specialist advisor to the Operational Research Section of the Ministry of Transport and Civil Aviation, in connection with aircraft queueing problems considered in the design of London Airport. He has similarly served the Commercial Banks in examining the possibilities of the machine handling of the cheque clearing system, and has published a number of mathematical Papers.

While on the staff of Imperial College, he made himself an electronics expert, and designed and built his own special high-speed electronic digital computer.

Dr. Tocher took up his present appointment early last year, and now controls the Electronics Laboratory, established for the purpose of building special machines designed to assist in the speedy solution of complicated industrial problems which can be expressed mathematically, and is also actively concerned with operational research work in the field.

of linear programming, and I hope to say a few words about this.

In dealing with the description of queues in mathematical terms and its application to industrial processes, we shall do best to take some very homely examples, which are familiar in our ordinary life as citizens. There are many lessons we can draw from the similarities and differences in these examples which will be useful to us later in understanding what a complete mathematical description of a queue has to contain.

simple examples

I suppose the simplest queue of which any of us have experience is that at a booking office at a railway station. Here exactly the same procedure is gone through with every person who comes to buy a ticket. His ticket is found and stamped, money exchanges hands, he goes away, and a new man comes to be served.

Every single person going to the ticket-clerk is treated in the same way. It does not take the same time to serve every person, because — for instance — one man gives a large sum of money and wants change, while another gives the exact money. There will be variabilities in the time of service. Viewed from outside, however, every person has the same probability of a given service time. This is the simplest form of queue with one server. That is an essential feature.

Let us consider the queue before a football match, where everybody has an identical objective of wanting to buy a ticket to see the football match. It will take the same time for each person to be issued with a ticket and taken into the ground. There is no longer one person serving; there are many entrances. We have a situation where many people are serving the customers. In this case there is a common objective and a common service, but more than one person is offering that service.

Now take the case of a cinema where people do not have a common objective. Some want the circle and some the stalls; some want to pay a lot of money and some very little. They, therefore, form themselves into different queues for different purposes, or into a common queue at a common ticket office to buy tickets of two different sorts. They are there for two different reasons and there will be two quite distinct service time distributions.

The final and most simple example of all, one we all know about, is the most complicated one to describe — the housewife going to buy groceries. There are many places of service for the customer to go in turn from counter to counter. There is a series of queues one after another. As the customer moves from place to place the service time is slightly different at each place. Some people want half-a-pound of sugar; some people want the whole of the week's groceries. So we have at the grocery store all the complications of the queue we are ever likely to find. There are several people serving each of several completely separate queue positions, giving differential service.

Finally, there is the situation that you probably do not recognise as being a queue situation at all, and that is with the telephone service. No doubt on many occasions you have found that the number you want is unobtainable. This very rarely means that the number does not exist. It merely means that the equipment in the telephone exchange is unable to connect you, because all the equipment is busy making connections for other people. We have a queue for the services of the equipment in the telephone exchange, as this equipment is all used up and you have to wait until someone ceases to use one of these pieces of equipment, so that it can serve you.

The difference in this case is that the General Post Office do not allow you to wait. You must go away and come back again. This is a form of queue we are not particularly familiar with in any other circumstances. It is what in their parlance is called "lost calls lost". In some American systems this does not hold. If you are unable to be given service now and you wait a little while until equipment becomes available, you can be served, and the classical queue situation is apparent to you.

I have dwelt at some length on a large number of domestic queues because they contain something which will be familiar to us all and which bear in one form or another on industrial queues. It is not clearly recognised, I think, that nearly all the processes in a large and complex works can be regarded as queue formations, and when one does so regard them, one realises that there is a very common foundation and there will therefore be a common mathematical formulation for these problems in terms of one single model, which will describe the situation merely by a change in the meanings attached to the terms of the model.

industrial queues

As an example of an industrial queue we can take the air transport industry, where there is a problem very like one of our domestic problems. Aircraft have to queue over an airport waiting to be allowed to land and use the runway. The service being offered is the use of the runway, and the aircraft can only use this one at a time. We all appreciate that it would be fatal if more than one at a time tried to use the runway. The queue is formed of a stack of aircraft travelling in circles in the air at different heights. As each aircraft lands, everyone moves down the stack, so there is a queue in the ordinary conventional sense in which we recognise it at the bus stop.

Reverting to the example of the taxis, the whole purpose of industrial plant can be phrased as a very similar situation, where orders can be regarded as the equivalent of taxi cabs and production as the equivalent of persons. We are trying to marry production and orders so that when orders are given, production is there to meet it. Equally, it is important that orders are there to meet production.

The situation, I suppose, in a works which would most closely concern this audience will be the despatch department of an industrial works, where one can see this very clearly in terms of queues. There are certain limited facilities for wrapping the goods

up, putting them in parcels or packing them in boxes, putting them into lorries and sending them away. There is a continual flow of material into the department, but neither the process of packing nor of despatching is regular. There are local irregularities. Even if the process of production is regular this will result in fluctuations in the amount of stock held in the despatch department, and if production is irregular the fluctuations will be emphasised. In these circumstances, we run certain risks, especially when dealing with a large number of different commodities. The demand for any given commodity may exceed the supply for a short time and, therefore, the demand will not be satisfied. This, all the commercial people assure you, has disastrous effects on the customer's good will. On the other hand, we may find ourselves with demand that has fallen off while the supply continues to increase. Stocks rise and overcrowd the warehouse. This again will cost us a lot of money.

avoiding extremes

We are in the situation that we have the two extremes which we must try to avoid. We must see whether it can be avoided by regulating the size of the stock and the size and capacity of the service; whether local fluctuations which do occur in production and demand will cause fluctuations in stock size to be so great as to cause us to run either of these two risks. To a great extent this is just the problem of asking whether the queue waiting at the booking office will ever become zero, or ever become so big that the booking hall is completely blocked.

The seeming triviality of discussing these domestic cases and thinking in these terms begins to disappear in the light of these examples. One can often describe particular industrial problems in exactly the same way as ordinary domestic cases. Consequently, when mathematicians deal with queues, they deal with them as though they were domestic queues, even though they do not really think the results would be applied in such cases.

I want to mention, for reasons you will see later, two other cases of the industrial formation of queues. One arises in the railway marshalling yards where railway wagons, having been emptied of goods, are pushed on to a siding and left to wait for the time when they will be wanted again. The railway siding is a service to the railway wagons. The difference between this and most of the queues we have discussed is in the rule of service. Previously this has been first come, first served. On the railway siding, because of technical limitations, it is exactly the reverse — first come, last served. Wagons pushed to the end cannot get out until all those pushed in afterwards have gone.

I am now in a position to give a mathematical description of queues.

People are arriving and departing. The number of people arriving and the number of people served will have to be specified. We shall have to specify in some way how they depart, or more accurately how long they stay to be served. It will also be necessary to specify the rule of choice of the next person to be served; the queue discipline, as it is called.

How can arrivals be described ? The ideal, I imagine, would be arrivals at equally spaced intervals, but in fact, even in the best arranged process, intervals will not be equally spaced. There will be irregularity in the arrivals, and we cannot predict what the next interval will be. This would be asking us to predict all those factors which we do not wish to bother with. Instead of talking about each individual interval, however, we can describe the pattern of intervals. This is achieved by determining a frequency distribution of these intervals. That is to say, for any given interval the relative frequency of its occurrence can be determined and the results for all possible intervals gives a description of the pattern.

In precisely the same way the times people take to be served will not be constant, but will fluctuate and can be described in terms of frequency distribution. Thus, the theory handles the pattern of arrivals and service in terms of frequency distributions.

The usual discipline is that of the democratic principle, first come, first served. In our examples of football matches, service is much more random and perhaps whoever is strongest is served first. The decision on who is served first is no longer dependent on the order in which they come to the queue. There is random service.

Sometimes, there is the sort of service one gets with railway wagons ; first come, last served.

In any given situation, the size of the queue will not have been influenced by the queue discipline. If one person goes away, the queue is diminished by one. If another person arrives, it is increased by one. It makes no difference how these people are chosen. But when we are inside the queue and wish to be served, a very large difference appears. With first come, first served, the waiting time is proportionate to the length of the queue. With other queue disciplines this is no longer true.

This means that as far as the application of the results is concerned, when we are concerned with the size of the queue and the amount of space that queue will take and the cost of maintaining the space for that queue, we are not interested in queue discipline. If, on the other hand, we are concerned with the passage of the material and the time it takes, we are interested in the queue discipline. According to which of these two aspects of the queue we are dealing with, the emphasis on queue discipline will be different.

So much for seeing what the description of the queue will be before a mathematician can start to handle it. What will be their results and how will he present them to you ?

First, as we have not been able to describe the input and service in deterministic terms, we cannot expect to get a deterministic result. Both queue length and waiting time also fluctuate. We can only specify these in terms of relative frequencies. Thus, we can calculate the probability that the queue length will be any assigned values, and the complete

set of these statements gives a frequency distribution of queue size.

It is rather difficult to absorb a description of that kind, because it is quite complicated, and it is desirable to condense this description. The two main characteristics are the mean level about which the queue will fluctuate and some measure of this fluctuation. This is done through the mean of distribution and its variance, which is a statistical description of the amount of fluctuation.

practical prediction

We can predict the distribution in any given queuing system, given input, service time, number of servers and, therefore, its parameters. Now we can ask ourselves questions. If we increase the number of servers what will happen ? If we decrease the service time on an average by so much, what will happen ? We have a tool to judge whether it is worth putting any effort into making these changes. On a prior judgment it may be possible to reduce the service time at some point by a minute. Suppose the effort likely to produce that reduction can be judged. Is that effort worth while ? Is the reduction of queue resulting worth while ? Would I not be better advised to carry on in the old way ? Would it be better to increase the service facilities by one other server ?

There is still a subjective judgment to be made as to the relative changes in costs created by these changes, but we have at least some practical and tangible prediction as to what the results of changes will be. This enables us to make a much closer and more balanced judgment of what is the best thing to do. If we can estimate the cost of an extra server, or the cost of the extra equipment and the savings created by smaller queues, we can make an economic balance.

In talking about the distribution of queue size we have made a simplification.

If the queue is at this moment empty, the probability that there will be 500 people two seconds later is very low indeed, whereas if there are 501, the probability that there will be 500 in two seconds is high. So the distribution of the queue depends on the initial state, the state it is in now.

The distribution discussed earlier is the distribution at a random time when the random elements have completely eliminated the effect of the initial conditions. Thus, it has been assumed that the queue system will go on indefinitely. This is perfectly fair and reasonable in most plants. They will go on a long time and the process will go along with it, but in these circumstances will the distribution be stable ? In a deterministic system where people arrive and leave on the clock, it is clear that if they arrive at shorter intervals than they go away, a queue can form and develop and grow indefinitely. This is not a stable situation. It is also clear that if people arrive more slowly than they leave, the queue will fade away and finally there will be no queue. In this case, the service will be under-utilised.

In the intermediate stage where the two are exactly balanced, the state of affairs will be satisfactory. The queue will wander from 0 to 1. If the elements of the process are in phase, it will be exactly 0. One person will come in and be served and as he passes out another will come in. This is a controlled situation.

Let us turn to the state of affairs where we are no longer dealing with regular events. A very similar pattern of cases will occur. If the average rate of arrival is faster than the average rate of departure, whether the system is deterministic or irregular, the queue will develop indefinitely. But if the arrival rates are lower than the departures, the queue will not, in the stochastic case, fade away completely. There will always be a probability that arrivals have exceeded departures, and therefore there is a queue.

This is the important difference that occurs when we take account of chance fluctuations, which may, even though quite small in themselves, cause appreciable queues to build up.

When we come to the balanced case when the average input equals the average output, we are not in a stable situation in a stochastic case. The queue size is transient. It will move very slowly but once it has moved it is very unlikely to move again, so that if the queue develops and gets bigger it will remain large. On the other hand, if it shrinks to zero possible service time is lost and this causes the queue to develop again. The queue can more easily go up than down when the system is in the balanced situation. Consequently, if you try to balance input to output, to put things into a system just as quickly as the system can theoretically absorb them, you will find a queue developing. This has important consequences in determining the amount of service and equipment you will provide.

an unstable situation

If you provide just enough, you are also providing a lot of trouble. In these circumstances, the situation is unstable. You can only successfully work a process of this kind when variations occur by under-utilising the service. The mean queue size can be calculated as a function of the relative utilisation. For unit relative utilisation the queue size is infinite, while for zero utilisation (and then zero relative utilisation) it is zero. The curve of mean queue size plotted against relative utilisation is J-shaped.

Curves of this kind are useful if the cost of a given size of the queue can be given, as is often the case. A queue carries a cost proportional to its size in respect of depreciation and interest on capital involved in the holding of the stock, and there are also constant charges. In the same way, utilisation can be given a monetary value. This, being proportional to the productivity, is proportional to utilisation.

We can balance one cost against the other and so get an overall picture of the cost of the process. The total cost curve is U-shaped. We will then have a minimum point and an optimum value for the utilisation of the equipment to minimise the total cost. If you over-utilise beyond that value, you will not be using the equipment in the most profitable way. Equally, if you under-utilise it you will also not be using it in the most profitable way.

Similarly, decisions as to the amount of service required can be made. Suppose there are five parallel service facilities. Is that the most economic number ? The mean queue size can, for a given utilisation level, be calculated as a function of the number of servers, and converted into a cost function. A balance can be made in the same way as before. Once again a U-shaped curve results and the optimum number of servers can be obtained. This can be repeated for different utilisation levels, and the optimum number of parallel services required, and their optimum rate of utilisation to maximise profit or economise operations, can be discovered.

a descriptive theory

This is a descriptive theory, and we have seen how it can be used to predict what will happen and to make decisions. It predicts the effects of chance fluctuations in input and output. If nothing is done to control these fluctuations a situation develops which is unsatisfactory. Any engineer who sees something out of control wants to control it. Just as physical situations are controlled with servos and feedbacks, so the flow of materials can be controlled in this way.

Take the simple example of a pendulum. If you give it a slight kick — neglecting air friction — it will swing indefinitely. You have disturbed it from a stable position and set up an oscillation. That oscillation will never die away. It does in practice, of course, and we know why. It is because certain dissipative forces are involved. But if we want to make the pendulum come back to the stable position, as quickly as possible, we artificially increase the dissipative forces and put damping factors in. We use a dashpot and stop the oscillation altogether. After the first outward excursion, it rides smoothly and gently back to the stable position.

We can follow the analogy of the pendulum in both practice and mathematical theory by applying servo mechanisms in flow systems.

Suppose we want inventory stock at a certain level. This stock is continually being changed by the rate of withdrawals to satisfy orders. It is continually being replenished by arrivals from production, and the relation of the two gives the differential of the rate at which the stock is moving.

You may control the input of that system, so that when you have large departures from the optimum state you want a change in the stocking rate. You may cut down production if departures are low, or speed up production if they are high. You have a situation similar to that of the pendulum. If it goes to the left, you kick it to the right. And, just as with the pendulum, you will set up an oscillation that will never die away.

information feedback

This will not deal with the situation. You must design a feedback of information about the inventory. You want to know not merely how big it is now or how far it is from the optimum, but how it is moving away from the optimum. Is it moving away from or towards the optimum ? You must take the rate of change of the inventory into account as well, and that is the same thing as putting a damping factor into the flow system, in the same way as you put a dashpot into the pendulum system.

In this way, one can obtain an ordering system in which production is geared to stock to eliminate to the maximum extent the effect of fluctuations in demand. This is what is required.

If one goes into the mathematics, one finds very quickly that what one wants is a crystal ball, because there is a gap between ordering and the arrival of the production at the stock department. Consequently, ordering now will affect the situation in the future. In order to reach a decision now we want to know what the future will be, and we never shall. Once again, we cannot know with any certainty about the future; but we can always think of it in terms of probability and consider the probabilities involved in various sets of conditions.

In terms of such a stochastic description of the future, one can design a model for an orders/production system. We can take the pattern of behaviour of the plant now and by considering certain probability distributions minimise the effects of such fluctuations as may occur in the future.

This application of classical mathematics and servo mechanisms to production control is rapidly gaining momentum. There are two differences from classical theory. One is that one never deals with the continuous motion of material, as one does when one writes down differential equations to describe the motions of mechanical things, Also, time is not continuous because there is no continuous control. You are not continually ordering material. There is a discreteness about the situation which is essentially different from the continuity in mechanical systems. This changes the mathematical apparatus a little but not sufficiently — luckily — to make it more difficult.

mechanical systems

Mechanical systems behave deterministically. You push a pendulum in the same way as yesterday, and it will behave in the same way as yesterday. It is not so with a social or production system, because we are not taking into account all the factors involved, as we can reasonably do with a pendulum. We can ignore the thermal agitation of the molecules because they are unimportant. We cannot reasonably ignore the equivalent thermal agitation of the social system because it is important. Consequently, the model has to be more complicated. It has to take account of processes which do not come into mechanical analogues.

Very fascinating prospects are opening up in dealing with classical formulae and servo control in a stochastic situation. There are very rapid developments taking place, and we have great hopes of them.

another application

We now turn to the other application of mathematics mentioned in the introduction.

This is a problem where we no longer consider the fine detail and the inner workings and interactions of the system, but take a broader overall picture. We deal here with the strategies of the utilisation of equipment and material at our disposal.

This was first realised to be a problem in the last World War. We were faced with the problem of shipping various strategic materials from various ports in America to various ports in Britain, and to do this so that the cost of doing it was minimised. This meant routing the traffic flow along various routes from ports in America to ports in Great Britain, taking account of the relative cost of transport. This was governed by the size of ships that could get into the docks, the load they could take, and the cost of transport to and from the docks.

This is a problem in which there are restraints. One of the restraints is that all the traffic landings must be positive. A second restraint is that there will be a limit on the shipping load on any given route. This is mainly caused by service facilities at the two ports involved; they can only take so many ships in a month. This affects the movement of tonnage from one place to another. We have limits at the two ends, so the cost itself is a weighted average of the costs of transporting on the different routes. The problem is to determine the weights which minimises the cost.

The weights are subject to linear restraint in that they must lie between certain fixed limits, and so the mathematical pattern reduces to determine the values of variables which will minimise a certain linear function, subject to certain linear restraints. Suppose we are given three ports at one end and five at the other, and the appropriate costs of shipping on all possible routes. With pencil and paper and patience one can work out the solution quite easily.

This may take a few hours, but if you have 50 or 100 ports the whole problem becomes quite impossible to solve by trial and error.

One wants to develop a whole science on how to solve these problems. There are pure mathematicians who are content to say they know there is an answer but are not interested in what it is. But in our application, it is the answer itself that is of value to us. Mathematical methods of finding this have been developed on both sides of the Atlantic in the last five or six years. Needless to say, it is not easily done with pencil and paper and involves lengthy calculations. Our latest tool is the electronic computer.

If I have given the impression that all we can now do is to solve the transport problem that arose in the last War, that is not correct. This is how it began — out of the transportation problem, but the general mathematical formulation can be applied to a host of other industrial problems. These concern multi-plant companies or multi-product plants using common services of raw material. The problem then is how to proportion production to maximise profit.

In the chemical industry, for instance, there is the problem of determining the optimum mixture of certain chemicals to make a fertiliser to a given specification, taking account of the relative cost of certain raw materials and processing cost, of the limits of the market for providing the materials, to minimise the cost of manufacture. In such a problem there may be up to 30 or 40 variables, and it can only be tackled by mathematical analysis and linear programming.

I hope I have given you a glimpse of how the mathematician looks at these problems and works upon them; of how he converts them into mathematical descriptions to which he can find solutions. I hope I have shown you how he can then turn round and think of their real meaning in terms of industrial production and put it to use in the handling of materials.

RESEARCH PUBLICATIONS

The Institution is advised by PERA that Dr. G. Schlesinger's book on "Accuracy in Machine Tools: How to Measure and Maintain It" is now out of print and cannot, therefore, be supplied. The following I.Prod.E. publications are, however, still obtainable from PERA at "Staveley Lodge", Melton Mowbray, Leicestershire.

"Practical Drilling Tests" by D. F. Galloway and I. S. Morton. Price 21s.

"Machine Tool Research and Development" by D. F. Galloway. Price 10s. 6d.

JOURNAL BINDERS

Strongly-made binders for the Institution Journal, each holding 12 issues, may be obtained from Head Office, 10 Chesterfield Street, London, W.1, price 10/6 each, including postage.

The Manufacture and Application of TUNGSTEN CARBIDE in Australia

by **W. J. Kelsey, A.M.I.Mech.E., A.M.I.Prod.E.**

THE object of this Paper is to study:- (1) The development; (2) manufacture; (3) standardisation; (4) tool fabrication; and (5) applications of cemented tungsten carbide within the Commonwealth.

(1) Development (Table 1)

The properties of tungsten carbon alloys were first investigated in 1893. A few years later, tungsten carbide was discovered, samples being produced by casting the alloys, but due to the high melting points, which are in the region of 3,000°C., practical difficulties were enormous. (Cast carbide is used today for sand-blast nozzles and similar applications.) This cast carbide had a grain size both coarse and uneven, which proved unsuitable for use in cutting tools, and would not polish sufficiently for it to be used as drawing dies.

During the First World War, Germany commenced development work on tungsten carbide, seeking a metal to act as a substitute for diamonds in the wire drawing industry. Krupp workers, together with scientists from the Osram Lamp Factory, surmounted these difficulties by applying the principles of powder metallurgy. It was found that a compact material relatively free from porosity could be obtained if the tungsten carbide powder was mixed with a metal powder of lower melting point, pressed into suitably sized ingots and heated to a temperature slightly above the melting point of the metal added. Cobalt proved to be the most suitable metal to add, although iron and nickel were tried.

Drawing dies and tool tips were introduced to the German market in 1926, to England in 1927 - 1928, and to Australia in 1929 - 1930, and England commenced manufacture and exportation of tungsten carbide in 1931.

It was not until 1941, when the stress of war-time economics began to be felt in the Commonwealth, that an investigation was begun into the production of tungsten carbide.

Research work was undertaken by the Metallurgy Department of the University of Melbourne(1) on

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The author of this Paper, which was presented to the Melbourne Section of the Institution in July, 1956, is Technical Sales Manager (Carbide Division) of Wickman (Australia) Pty. Ltd.

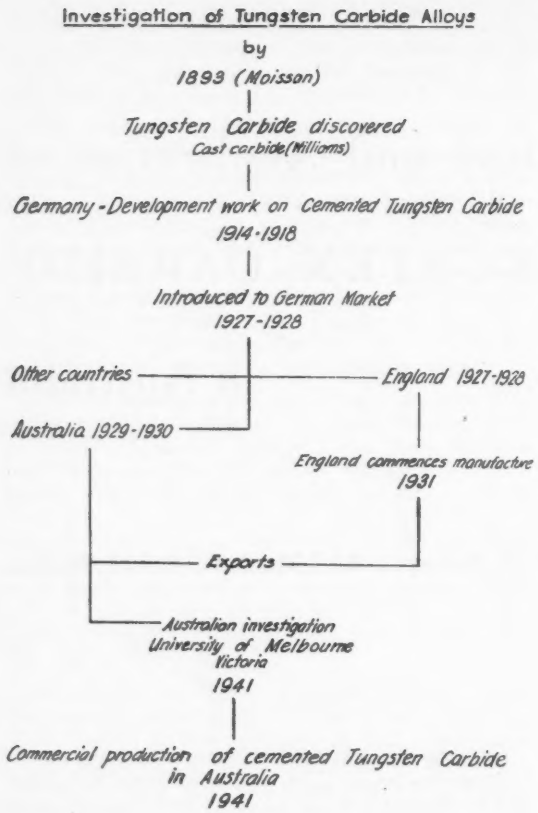

Table 1

problems associated with the production of tungsten carbide from local raw materials, and the pressing of such into tips for cutting tools. The tungsten carbide was prepared from King Island scheelite, and cobalt from crude cobalt oxide obtained from Risdon.

Two mills were used for grinding the powders to a suitable size, and for mixing the tungsten carbide powder with powdered cobalt :

1. a porcelain mill 5″ dia., 5½″ in length ;
2. a stainless steel mill 7″ dia., 5″ in length.

The mills were loaded with a ball load twice the weight of the charge, and the grinding medium was cobalt pellets. By this means any contamination by the grinding medium consisted of the metal to be introduced.

Two types of compacts were made :-

(a) Small cylindrical pellets weighing about 5 grams — approx. 0.4″ dia., 0.3″ thick.

(b) rectangular bars weighing about 6 grams — approx. $1\frac{1}{4}'' \times \frac{1}{4}'' \times \frac{3}{16}''$ (as pressed).

These compacts were made in hard steel dies, using a 30-ton Amsler press, (of which there was only one available).

The pre-sintering and sintering operations were carried out in a carbon tube furnace with a purified hydrogen atmosphere.

Initial experiments were made using the porcelain mill and a mixture consisting of tungsten powder with approximately 8% cobalt powder :

(a) composition ground for 30 hours in a porcelain mill at 65 r.p.m. ;

(b) composition ground for 72 hours in a porcelain mill at 65 r.p.m.

The analysis of the two batches after milling were as follows :-

	A	B
Cobalt	9.1	12.2
Insoluble (siliceous matter, etc.)	2.1	3.3
Iron	0.8	0.8

The increase in cobalt content is due to the abrasion from the cobalt pellets used as a grinding medium. These materials were pressed, pre-sintered for one hour at 900°C. and finally sintered for half-an-hour at 1,400°C. All samples had an inferior density, and by elimination it was decided that the porcelain mill was responsible, as the porosity increased with the longer milling period.

Experiments with the stainless steel mill, using the tungsten carbide from the same batch as used for compositions A and B, gave the following analysis after milling for 24 hours at 65 r.p.m.

	C
Cobalt	9.25%
Iron	1.13%
Insoluble ...	0.6%

The specimens were pressed, pre-sintered and sintered, and all samples from batch C had better density and hardness values. Therefore, all further experiments were made using this mill.

Several small bars of the most satisfactory cemented tungsten carbide were mounted on steel shanks, and used as lathe tools. These tools behaved well, particularly when cutting cast iron.

Between 1941 and 1943, three industrial concerns commenced commercial production of cemented tungsten carbide. By 1952, four firms with plant available for a capacity in excess of 15 tons per annum were in production.

(2) Australian Manufacture of Cemented Tungsten Carbide

The manufacturing methods shown in Fig. 1 are general ; the various companies alter or modify equipment and methods to suit their own products.

The main raw material used in the manufacture of tungsten carbide is tungsten oxide, prepared in its pure form from tungsten ore (scheelite or wolfram), by companies specialising in this treatment.

Tungsten Metal

Tungsten oxide is converted to tungsten metal powder under carefully controlled conditions. The tungsten oxide is weighed out into heat-resisting steel boats or containers, and stoked (in most cases automatically) through an electrically-heated,

temperature-controlled furnace at about 900°C. in an atmosphere of pure dry hydrogen. The purity of the hydrogen is important and extreme care is taken by the users to remove all but slight traces of oxygen and water vapour ; the gas is either produced adjacent to the carbide plant, or purchased in cylinders and purified before use.

By rigid control of this reduction process, a uniform product is assured and particle size kept within the desired limits. The end product, tungsten metal powder, must show a purity of at least 99.9%, with a uniform and fine grain size, as this powder will influence the completed tungsten carbide. Samples are taken for determination of purity and grain size.

Tungsten Carbide

Assuming that samples taken from the previous process conform to the desired specifications, the tungsten metal powder is mixed with slightly more than 6% carbon (in the form of lamp black) in a ball mill for several hours to obtain an intimate mixture. The mills are of stainless steel alloy, and carbide balls of various sizes used for the grinding medium. At the conclusion of this ball milling operation, the mixed powders are packed into graphite boats and heated in a hydrogen atmosphere for several hours at temperatures ranging from 1,400°C. to 1,600°C., during which chemical combination takes place between the tungsten metal and the carbon, producing tungsten carbide. Samples are taken for determination of total and free carbon, both of which must be controlled to very fine limits.

Cemented Tungsten Carbide

Cobalt metal powder, the percentage depending upon the grade of material required, is added to the tungsten carbide. Accurately weighed charges of these materials are thoroughly mixed in a ball mill for a period depending upon the cobalt content, with the object of obtaining an intimate mix and a smearing of the tungsten carbide particles with cobalt. Milling is carried out wet, using distilled water, or one of the acetones. The sludge is centrifuged and dried out in vacuum ovens, the dry powder being then sieved through a series of fine metal screens to remove oversize particles. Samples are taken for chemical test and test pieces sintered for structure and porosity test.

Cemented Tungsten Titanium Carbide

Carbides of steel cutting grades are produced in a manner similar to that for tungsten carbide, with the addition of the titanium carbide at the milling

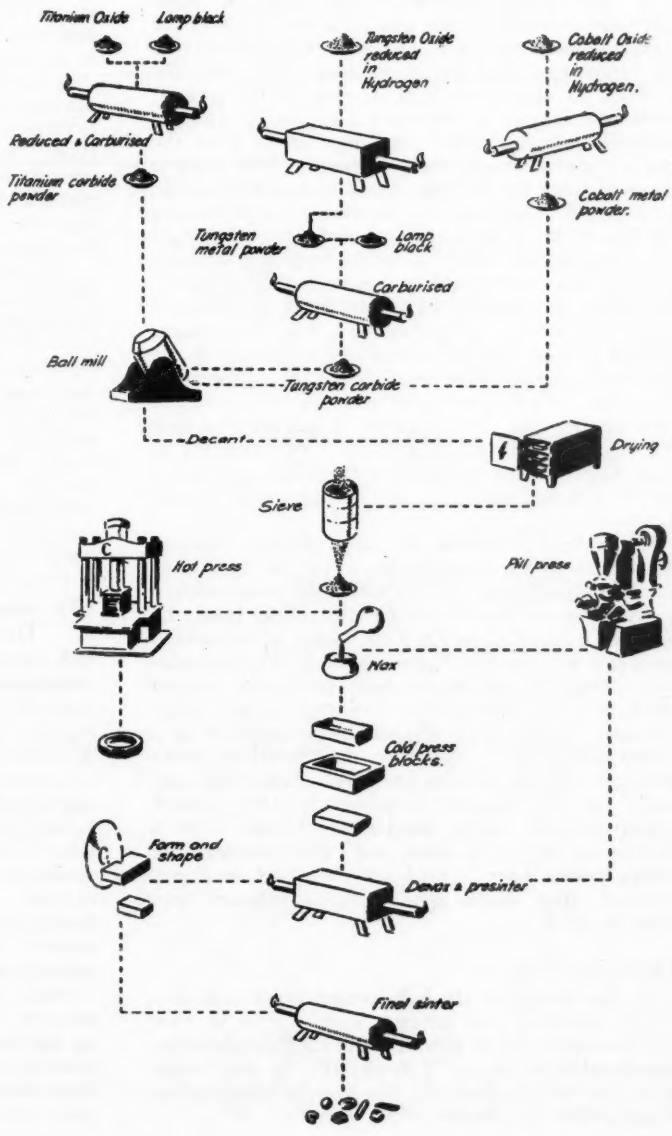

Fig. 1. General manufacturing methods.

stage. These grades, which contain titanium, possess a lesser tendency to weld to steel during machining operations, hence the term " non-cratering ". However, the addition of titanium does lower the strength of the finished product, therefore, high titanium grades are used for finish machining of steel, and low titanium grades for roughing.

Production of Useful Shapes from the Powders

Two methods of producing useful shapes from the powders are :

(a) cold pressing of ingots for small quantity batches, and complicated shapes ;

(b) cold pressing for large quantity batches of plain or simple shapes.

In the former method paraffin wax, or other lubricant, is added to the powder after weighing the correct amount required. This is then introduced into the large segmental die, care being taken with the packing, as due to the lack of flow of the powder even distribution is necessary to give a uniform pressing. An hydraulic press is used to form the powder into a fragile ingot or block. The ingot is removed from the die after pressing and the paraffin wax, or other lubricant, is removed by a de-waxing process. This process consists of heating the ingot to a temperature of 400°C. in the hydrogen furnace, the wax being driven off in a gaseous form. Due to the fragile nature of this ingot or block of cemented tungsten carbide, a preliminary heat treatment, termed pre-sintering, is carried out in the automatic temperature controlled furnace at a temperature of from 700°C. to 1,000°C., in a hydrogen atmosphere. This temperature is adjusted to give the required hardness of the block. Partial sintering takes place, which strengthens the block, so that it may be handled with due care, cut, turned or formed to shape.

In the second method, for large quantity batches, the press used for large batches of simple shape is of the automatic type (pill or tableting press) with a gravity hopper feed. Rapid die filling from the hopper is essential so the flow factor of the mixed powder is increased by " granulating ". This granulation is carried out by crushing previously pressed blocks of waxed powder to a controlled size. High pressures are required to crush these granules to a close packed form, therefore, for repetition work tungsten carbide die sets are used. Generally only simple or plain shapes are formed by this method, typical examples being standard tip blanks, when a plain form may be pressed, and radii and clearance angles added later. Tips are de-waxed and pre-sintered, after which any additional shaping may take place.

Final Sintering

In this operation, the soft formed blanks are converted into the hard tungsten carbide tips as used for the machining of metals. During final sintering, considerable shrinkage of from 20% to 30% takes place, for which allowance has been provided when shaping the soft blanks.

The shaped blanks are loaded into graphite boats, using a refractory as a packing to avoid fusion between the tips. Boats are then fed into the furnace, and heated from 1,350°C. to 1,600°C. in a hydrogen atmosphere for several hours. In common use is a type of furnace which uses a carbon tube as the heating element, through which the work boats are automatically stoked at speeds depending upon the size and grade of the tungsten carbide blanks. Final sintering must not be confused with the term hardening as applied to conventional heat treatment; it is instead an operation in which the hard particles of tungsten, or tungsten titanium carbides, are bonded (or cemented together) by the matrix (cobalt).

Hot Press for Hot Moulding Process

This process is used for the production of shapes in which better control of contraction is necessary, and when undue distortion of large thin sections is to be avoided.

A method used in Australia is that of a press having the carbon mould heated by a high frequency induction unit. The moulds may be of the " closing type ", that is, they are so dimensioned that the correct size carbide blank is produced when the plunger has compressed the carbide mixture, and the outer end or ends of the plunger are flushed with the die barrel.

The volume of carbide mixture poured into the die is calculated by weight from the known density of the required finished product, punches and die are assembled and positioned under press, and the powder is pressed at a relatively low pressure. Simultaneously, heat is applied at a temperature similar to that used for sintering cold pressed carbide. Care must be taken not to under-press because porosity will result in the finished product, and on the other hand, over-pressing will cause excessive squeezing out of the cobalt binder, resulting in incorrect binder content and local segregation of cobalt, which again results in porosity, or soft spots. For this reason, compression of the carbide charge is measured with dial indicators.

(3) Australian Standards for Tungsten Carbide Tips and Tools (2)

A proposal was made in 1951 by one of the manufacturers of tungsten carbide to introduce an Australian standard, either by using an existing standard, or forming one to suit *Australian conditions*. This was followed by a meeting of interested parties, composed of tungsten carbide tip and tool manufacturers, and importers of English, American, and other carbides, at which a committee and sub-committee were formed. At this time, Australia had at least five standards, of English, American and Continental carbides. In order to avoid confusion and extra stocking, larger users formed their own standards and ordered from these, thus two or more standards were added to the already impressive list.

Both committees soon realised that a speedy solution would be impossible, due to the necessity of an agreement between the various importers and manufacturers. It was not until 1954 that an Australian Standard for tungsten carbide tips and tools came into being.

Table 2

AUSTRALIAN MANUFACTURED TUNGSTEN CARBIDE GRADES

Recommended Uses

Recommended Use	*Bromet*	*Carbaloy*	*Sintung*	*Wimet*
Cast Iron & Non-Ferrous Materials				
Roughing Cuts ...	CL	44A	C10	N-G
General Purpose ...	CK	883	C8	N
Light Finishing Cuts	CH, C1	905	C6	H
Precision Boring ...	C1	999	C4	F
Steels				
Roughing Cuts ...	SH	78C	S10	S58
General Purpose ...	SD-SG	78B	S8	X8
Light Finishing Cuts	SC	78	S6	XX
Precision Boring ...	SB	831	S4	FS
Wear Resisting ...	FO CK	44A 883	C6 C8 C10	N WR

PLUS ADDITIONAL GRADES FOR SPECIAL APPLICATION

The numbering system used for the tools is essentially the same as that adopted by America, tools being designated by a letter, the hand of the tool by "R" or "L" (right or left) and "C" (central). The shank dimensions are denoted by a number or numbers. This system differs from the American in that rectangular as well as square tools are identified by the width and height in sixteenths of an inch. This modification allows all tools, such as those for roller boxes, to be incorporated in the system.

EXAMPLES OF TOOL DESIGNATION

Tool No. A.R.6.

A = 90° Bar Turning Tool.
R = Right Hand.
6 = $\frac{3}{8}$" square.

Tool No. BL 1216.

B = 15° Lead Angle Tool.
L = Left Hand.
1216 = $\frac{3}{4}$" × 1" Section.

THE FIFTEEN STYLES OF STANDARD TOOLS

STYLE A—90° Bar Turning Tool.
STYLE B—15° Lead Angle Bar Turning Tool.
STYLE C—Broad Nosed Tool.
STYLE D—80° Light Turning Tool.
STYLE F—Off-Set Facing Tool.
STYLE G—Off-Set Turning Tool.
STYLE H—Cranked and Straight Round Nosed Turning Tool.
STYLE J—45° Cranked Turning and Facing Tool.
STYLE K—Off-Set Parting Tool.
STYLE L—Square Shank Boring Tool held at 90°.
STYLE M—Square Shank Boring Tool held at 45°.
STYLE N—Round Shank Boring Tool held at 90°.
STYLE P—Round Shank Boring Tool held at 45°.
STYLE R—Roller Box Tool.
STYLE S—90° Cranked Turning and Facing Tool.

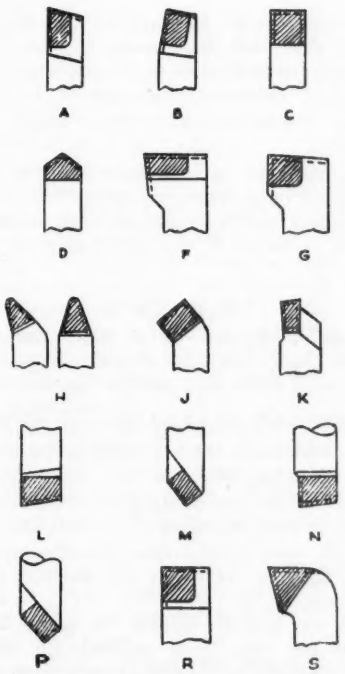

Fig. 2. The 15 styles of standard tools.

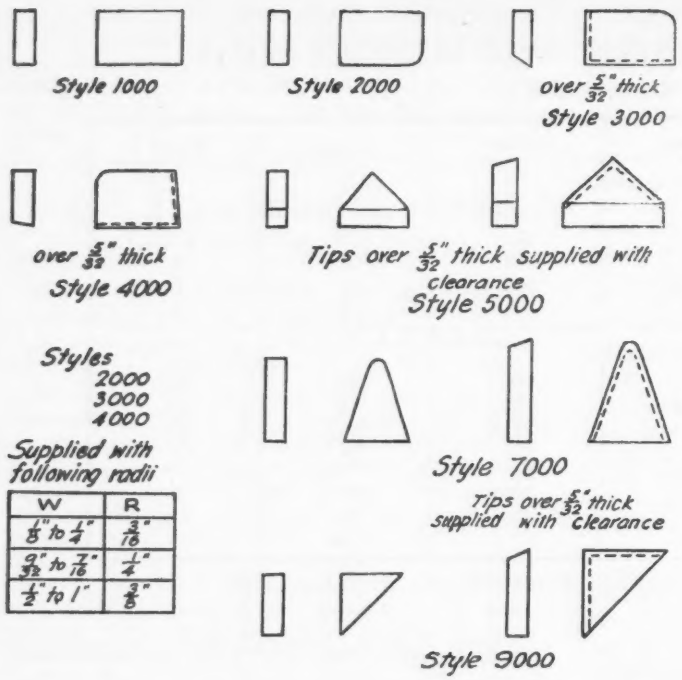

Fig. 3. Seven styles of tip blank

These tools are to conform to the design and dimensions that will be shown in the Standard specifications, bases of tools to be machined flat, and to conform to following tolerances on heights;

Shanks up to and including $\frac{3}{4}$" + 0.000" – 0.015"
Shanks over $\frac{3}{4}$" ... ... + 0.000" – 0.025"

Boring tools must be machined all over to tolerances specified in standards, parting tools machined top and bottom, and top rakes on tools, unless otherwise stated, must be 6° for all grades of tungsten carbide.

TIP BLANKS

These are designated by a series number and incorporate American and British shapes. They consist of seven styles as shown in Fig. 3.

AUSTRALIAN STANDARD TIP STYLES

These should be to the following tolerances :-

Up to and including $\frac{3}{8}$" ... ... + 0.015" – 0.000"
Over $\frac{3}{8}$" up to and including $\frac{3}{4}$" + 0.020" – 0.000"
Over $\frac{3}{4}$" up to and including $1\frac{1}{2}$" + 0.030" – 0.000"

Radii have been standardised, entailing the use of only three sizes of end mills for the full range of standard tools.

Although to date the official Standard Specifications have not yet been printed for issue, all Australian manufacturers and importers are producing to these Standards.

(4) Tool Fabrication

Tools are being manufactured by the producers of tungsten carbides and their associates, who supply a complete range of carbide tools, dies and wear resisting parts, or firms specialising on one or more of the following: single point tools, dies, masonry drills, woodworking and stone working tools.

Shank Material used for the majority of steel shanks consists of 0.4 to 0.6 carbon steel. Meehanite shanks are being used by several firms manufacturing their own tools.

Machining of Tool Shanks

Conventional methods are used for this operation, although production is assisted by air-operated jigs at some firms. Tip seatings are milled by tool manufacturers to give a "snug" fit to the tip. In the case of users producing their own tools, it is normal either to slash mill or to mount the tip direct to the top of the tool shank.

Brazing (Fig. 4)

Due to the low thermal expansion rate of carbide in relation to steel having twice the rate of thermal expansion, problems occur when brazing, the most serious being the cracking of the carbide tip. It is, therefore, recommended that the steel section under the braze should be in the proportion of 3 :1, and

never less than 2:1, the length of the tip to be a maximum of eight times the thickness. When these proportions are exceeded, the strains set up by the brazing operation may be relieved by the use of a sandwich braze, in which a shim of copper or nickel 0.005" to 0.010" thick is placed between the carbide and the steel, and brazing carried out with a low temperature silver alloy. Sandwich brazing is unsuitable for impact loads, as the copper may "beat out" during use and uneven support of the tip result in failure.

Brazing mediums used are silver alloys having melting points of from 1,200°F. to 1,600°F., brasses and copper with melting points of 1,600°F. to 1,980°F., or certain proprietary brands used with suitable fluxes. The copper braze is recommended for applications involving high temperatures. Finishing of the tip is essential on the mating faces to remove the thin surface layer produced during sintering which is not readily wetted by the brazing alloy; the tip and tip seat are then cleaned with carbon tetrachloride or trichlorethylene.

Brazing methods used are the oxy-acetylene, or gas torch, the brazing furnace and the high frequency induction set.

The induction method is the most convenient for mass production. In this process a formed heating coil is so arranged that heating is applied to the tip end of the tool, the coil being of single or multi turn. Brazing material (silver alloy) may be placed either on top or directly under the tip. When the tool becomes heated beyond the melting temperature of the silver alloy it is withdrawn, and the tip pressed down to remove excess brazing material. In the case of reamers having several tips these are held by wire or mechanical means during the operation.

Inert atmosphere brazing is carried out when a copper braze is required with the induction heating machine, the heating coil being arranged around a quartz cylindrical chamber through which hydrogen is fed from the underside, and allowed to burn off.

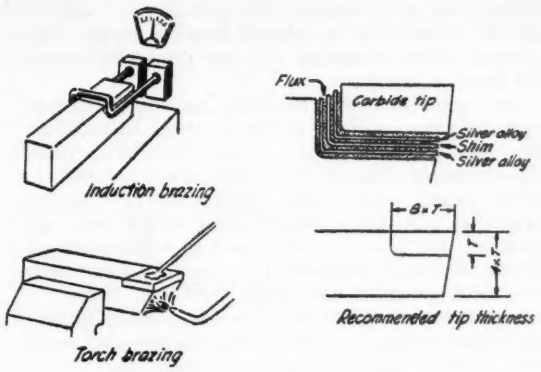

Fig. 4. Brazing.

Grinding and Lapping of Tools

In addition to off-hand, surface and tool and cutter grinders, we have more than 20 machines of the optical profile grinding type for complicated form grinding in Australia.

One machine basically comprises a universal grinding machine and a pantograph-controlled microscope, enabling complicated forms to be produced to an accuracy of 0.005" in a fraction of the time required by older methods. A 50:1 layout or drawing is produced of the form required, and mounted on the drawing table of the machine, the pantograph imparting a 50:1 reduction to its final arm in which is incorporated the projector unit. By successive repositioning of the stylus in the long arm of the pantograph along the line of the layout, the microscope is repositioned over the work, and so precisely traces the required form, the operator adjusting the grinding wheel to the centre of the graticule viewed in the microscopic field, and grinding proceeds until the work has been ground to the cross hairlines. The pantograph is then moved along the profile to the next stage and the same grinding procedure follows. Thus irregular shapes and curves may be ground without being affected by wheel wear, nor does the wheel require forming. The grinding wheel is stationary for circular forms and reciprocated for flat forms. Form drawings must be accurate, as an error of 0.010" means an error of 0.0002" on the work piece.

Certain Australian firms are already using the electro-erosion or ultrasonic machines to produce holes and contours in solid tungsten carbide for gauges and various types of dies, thus saving many manhours on forms that previously had to be split.

The electro-erosion or spark machine uses an electrode shaped in accordance with the form to be reproduced. This electrode is mounted in the head of the machine and positioned in relationship to the tool blank. A high voltage electric current is then passed through the electrode to bombard the workpiece, and disintegrate or erode the tungsten carbide in precise relationship to the electrode form. The process, once started, is completely automatic, erosion continuing until the required depth of form has been reached. A non-conductive or di-electric fluid (kerosene) covers the workpiece during the erosion operation.

The ultrasonic or electro-abrading machine is a purely mechanical process in which the fluid surrounding the tool and workpiece is a vehicle for carrying suspended particles of abrasive, while the tool is vibrated at ultrasonic frequencies by electrical means. Tools may be produced of mild steel or other soft materials; the abrasive consists of silicon carbide or boron carbide in water, this suspended abrasive either flowing through the tool or on the tool and workpiece.

It is understood that one tungsten carbide tool manufacturer is experimenting with electrolytic

grinding on a converted tool grinder. Tungsten carbide is removed by electrochemical means, the diamond wheel removing the soft insulating oxides that form on the work.

The manufacturing methods already described cover the general cutting tool production. In addition, firms are specialising in carbide wire, bar, tube, and extrusion dies. These dies are produced in several grades and various hardnesses of tungsten carbide to suit the application for which they are intended, and are normally cased in steel, although carbide nibs and pellets are purchased by some users who build up, grind and polish their own dies.

A complete range of wood working tools, including router-cutters, circular profile cutters and wood saws up to 48″ diameter, is being produced.

Only the simpler die sets are being manufactured at present, although firms who use these tools for applications such as the blanking out of thin section materials are purchasing the formed die segments and building up their own die sets.

PARTIAL LIST OF TUNGSTEN CARBIDE TOOLS MANUFACTURED IN AUSTRALIA

Standard tools ...	to Australian Standards.
Form tools	flat, circular, dovetail, skiving, threading, grooving, etc.
Reamers	solid and adjustable.
Drills	for non-ferrous and non-metallics, coring and counterboring, masonry and glass.
Milling cutters ...	solid and inserted tooth type; face, side and face, slotting end mills, hollow mills and saws.
Forming tools ...	for the spring, nail and tack-making machines.
Gauges	special — gap and plug.
Wear resisting parts	for the textile and engineering trades.
Rock drills	post hole diggers and the cutting of coal.
Tools for the stone and woodworking trades	
Valves and nozzles for the spraying of insectides	
Sand blast nozzles ...	(sintered).
Dies	for wire, tube and bar drawing, extrusion, heading, swaging and press dies.
Work rests and guides	for centreless grinding machines.

Table 3

(5) Applications

Tungsten carbide tools, in one form or another, are now essential to our economy, and are used not only by the large corporations, but at home for the drilling of brick walls, for plugging, by the dentist, the stonemason and cabinet maker. These tools are being used by hand, on belt-driven machines of questionable date, and in the most modern plants. Therefore, it is only possible to survey isolated cases of certain applications, those taken are on normal production figures.

The most common application for tungsten carbide tools is in the turning operation.

TURNING EXAMPLE No. 1

Component: Road roller wheel, 58″ dia., 16″ tread width.

Material: Steel Boiler Plate — Formed and welded in four sections to wheel shape.

Machine: Old type open bed lathe, belt driven through a 15 h.p. motor.

Operation: Rough turn and face.

Before these particular wheels could be machined, it was necessary for several modifications to be made to the machine. The feed was unsuitable, so a new gear chain was made to give a higher feed range (0.080″ per revolution). The existing tool box could not be used due to the wheel diameter, so a solid tool carrier was designed to clamp direct to the cross slide in place of the tool box, with an adjustable tie bar, one end of which was attached to the tool bar or holder in a position just behind the tool, the other end being secured to the machine. By adjustment of this bar, deflection of the tool holder was reduced and chatter minimised.

PRODUCTION FIGURES

Cutting Speed: 248 feet/min.

Feed: 0.080″ per revolution.

Average Depth of Cut: $\frac{1}{8}$″.

Tools Used: HR.16 (Round nosed — right hand cranked 1″ square) for facing the rim.

JR.16 (45° Cranked turning and facing tool — right hand 1″ square) for turning the outside diameter.

Grade of Carbide: Steel grade for roughing cuts.

Tools are interchanged in the holder, between operations.

A more complex method is that of copy turning, either by special lathes or copy attachments.

TURNING EXAMPLE No. 2

Component: Valve reel 14$\frac{1}{2}$″ in length.

Material: 1$\frac{1}{2}$″ dia. black bar 40-45 ton steel.

1st Operation: Four machining cuts.

The first consists of a straight turn, which removes $\frac{1}{8}$″ from the bar diameter, removing scale, thus relieving the internal stresses in the bar. The speed used for the first turn was 550 f.p.m. at a feed of 0.012″ per revolution. Three following cuts are then taken which follow the profile of the master, at a speed of 550 f.p.m. and a feed of 0.008″ per revolution. The maximum depth of cut taken was $\frac{3}{32}$′.

2nd Operation: The bar is reversed, and two cuts taken at a speed of 550 f.p.m. with a feed of 0.008″ per revolution, to form the end and remove the fillets left by the first operation.

Conclusions: Tool regrind every eight hours; cycle time for first and second operation per component was eight minutes.

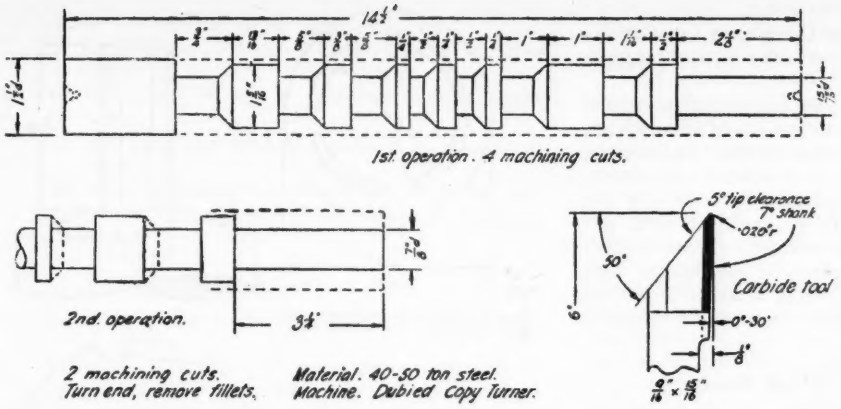

Fig. 5. See "Turning example No. 2."

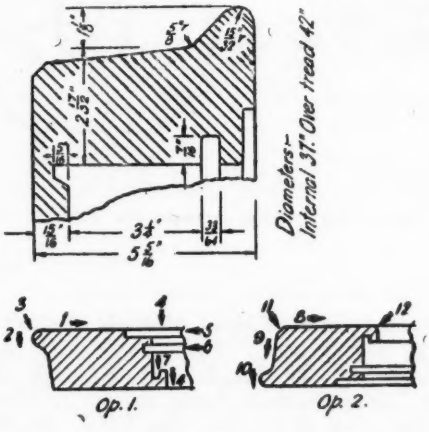

Fig. 6.

The feed and number of cuts taken were limited by the long thin component. When feed was increased or number of cuts reduced, deflection of the bar became apparent, as no bar steady is used.

A well known copy lathe copies external and internal profiles from a master or template, giving maximum metal removal rate and enabling tungsten carbide tooling to be used to the ultimate.

TURNING EXAMPLE No. 3

Component: Electric train tyre, 42" dia.

Material: "D" Class Steel. 56/62 ton forging, this being of irregular shape with hard inclusions.

Machine: 48" Webster and Bennett Boring Mill.

Operation: Tyre is turned, bored and recessed in two operations; for finished wheel profile see Fig. 6.

Table 4 — SEQUENCE OF OPERATIONS (*see also* Fig. 6)

Machine Face	*Description*	*Speed Ft./Min.*	*Feed/Rev.*	*Tool*
1	Turn Back	240	0.031"	T.C.
2	Turn Flange Dia.	240	0.031"	T.C.
3	Form Radii	50	Hand	H.S.S.
4	Bore	240	.021" feed reduced to .008" when facing shoulder	T.C.
5	Turn Back Recess	240	.031"	T.C.
6	Recess	240	.010"	T.C.
7	Recess	240	.010"	T.C.
8	Turn Front	240	0.031"	T.C.
9	Turn Tread Dia.	240	0.021"	T.C.
10	Turn Flange	240	0.031"	T.C.
11	Turn Chamfer	240	Hand	T.C.
12	Turn Radii	240	Hand	T.C.

Total floor to floor time per component (two operations) 2½ hours. General purpose steel cutting grade of carbide used.

Milling

Types of milling cutters being used in Australia vary from the single-point fly cutter to the multiple inserted tooth cutter.

Fly cutters are simple, easily made carbide tipped tools, mounted securely in tool holders or adaptors, and are usually run at very high speeds. Tool setting and grinding is carried out in a matter of minutes, compared with the long grinding process for the multiple-toothed cutter. Chip loads or feed per tooth of 0.005″ to 0.010″ are normally recommended, tool angles depending upon the workpiece and material. This type of cutter is used on machines having insufficient horse power for multiple-toothed cutters.

MILLING EXAMPLE No. 1

Component: Shearing knives $\frac{7}{16}$″ thick by 13″ long.

Material: Comsteel M9 — Silicon Chrome Steel.

Machine: 1922 Cincinnati horizontal milling machine — belt drive.

Cutter: 6″ diameter fly cutter, having a tungsten titanium tipped tool, $\frac{3}{4}$″ square section, with a 15° negative helix and a 6° positive radial rake and a 45° lead angle.

Speed of Cutters: 1,500 f.p.m.

Feed: 0.006″ per revolution or 5¾″/min.

Depth of Cut: $\frac{1}{4}$″.

Operation consists of positioning four shearing knives, one on top of the other, in a jig and taking two $\frac{1}{4}$″ depths of cut along the full length.

Tool life is short, eight components per regrind of tool, but this is offset by the speed of operation, and quick tool change-over.

Small diameter cutters of the router type are being used for brass, cast iron, and aluminium.

MILLING EXAMPLE No. 2

Component: Phosphor bronze blanks, already drilled ($\frac{5}{16}$″ dia.) for cutter entry. Blank size 5½″ diameter × $\frac{5}{16}$″ thick.

Operation: Consists of profile or router milling four $\frac{5}{16}$″ wide slots on a 2″ radius. Vertical milling machine used.

Cutter: $\frac{5}{16}$″ diameter router — solid tungsten carbide (non-ferrous grade) brazed into shank (Fig. 7). The cutter teeth have a 5° positive radial rake with a $\frac{9}{16}$″ length of flute.

Speed of Cutter: 200 r.p.m. (maximum on machine).

Feed: Hand feed is used at approximately 8″ per minute. The cutter is fed into the $\frac{5}{16}$″ diameter hole for the full depth of cut and the component rotated on a circular table.

Results: 300 slots or 75 components are milled (normal batch quantity), without apparent wear of cutter. Cycle time per component was 1½ minutes. Previous results with high speed steel cutters gave a cycle time of five minutes and 24 slots, or six components only were milled per regrind of cutter.

Another tungsten carbide cutter of $\frac{7}{32}$″ diameter has been manufactured and is giving similar results on $\frac{1}{4}$″ thick blanks of phosphor bronze.

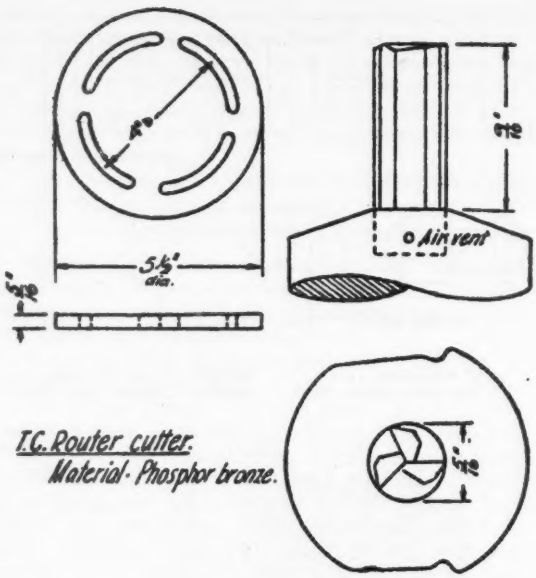

Fig. 7. See "Milling example No. 2."

Tungsten Carbide Tipped Multiple Cutters

These require rigidity of set up so that all chatter is eliminated. The machine should have ample power, cutter diameter being in the relation of 3 : 2, and feeds of not less than 0.005″ per tooth, unless a high finish is required in preference to tool life. For maximum cutter life, feeds and speeds should be so adjusted that dulling time due to abrasion and that due to cratering, are about equal.

In all cases when using multiple toothed cutters, it is advisable to refer to the metal removal efficiency factor given on most of the tungsten carbide recommended speed and feed charts, and starting with this information, to calculate from the width and depth of cut the most suitable speed and feed.

Formulae for Multiple Toothed Cutters

$$T = \frac{Eff \times HP}{a \times b}$$

$$t = \frac{T}{RPM \times N}$$

$$F.P.M. = .262 \times D \times R.P.M.$$

T = Table travel in inches/minute.
a = Depth of cut.
b = Width of cut.
Eff = Metal removal factor.
HP = Horse Power.
t = Feed per tooth.
N = Number of teeth in cutter.
R.P.M. = Revolutions per minute of cutter.
F.P.M. = Feet per minute of cutter.
D = Diameter of cutter.

Cutting angles appear to vary in the different factories, the general trend appears to be :-

For steel below 50 tons — positive helix negative radial.

For steel above 50 tons — negative helix negative radial.

For cast iron and brass — positive helix neutral radial.

The tougher grades of carbide are used for the positive rakes and harder grades for the negative rake cutters.

Multiple Toothed Milling

Component : Die block of high tensile nickel cast iron 17 to 18 tons.

Cutter : 8" dia. face mill, having 10 teeth with a 10° positive helix and a 10° negative radial rake ; the inserted blades are serrated for adjustment and held in position by wedges.

Speed : 97 r.p.m. or 205 feet/minute.

Feed : 8"/minute for entry of cutter into work-piece, then increased to 12"/minute.

Depth of Cut : Varied on irregular surface, from $\frac{3}{16}$" to $\frac{7}{16}$".

Width of Cut : 6".

Results Obtained : 400 cu. in. or 2,052 cu. in. per inch depth of cut of metal removed, with only slight cutter wear.

Screw Cutting

A capstan or turret lathe cutting technique developed in England for threads that are too large to be produced by self-opening die heads is now being used to great advantage in Australia. Threads previously produced by chasing tools at 30 to 50 feet per minute are being cut with tungsten carbide tools at speeds as high as 500 ft./min. on steel and 200 ft./min. on cast iron. In addition, heavier cuts are taken.

The screw cutting tool consists of a suitable grade of carbide brazed on to a shank, or a tangential clamped on tool. The tangential tools have the thread form ground the full depth of the carbide, and grinding takes place on the one surface only. When screwing to a shoulder, minimum width of the undercut is dependent upon the component diameter. For example, when cutting 11 to 14 threads per inch on a 3" diameter, an undercut of $\frac{1}{4}$" for steel, and $\frac{3}{16}$" for cast iron, is required. On work in the region of 10" diameter, the undercut should be $\frac{3}{16}$" for steel, and $\frac{1}{8}$" for cast iron. On internal screwing, the tool holder is attached to the rear tool post. The tool has a circular shank, the head having a brazed-on tungsten carbide tip on which the thread form is ground. For internal cutting of a right-hand thread, the machine spindle is run in reverse, with the tool cutting in an outward direction to assist in the swarf disposal.

Single Point Screw Cutting

Component : Trailer axle of chrome molybdenum (50 ton cast steel).

Machine : Ward 10/13 capstan lathe.

Operation : Screw cutting a $2\frac{1}{2}$" diameter, 12 t.p.i. National fine thread for a length of $1\frac{3}{4}$".

Speed : 350 feet per minute.

Four passes are taken to complete the thread form — thread is cut in one minute per component.

The Cri-Dan high speed threading machine providing a semi-automatic means of cutting threads with single point tungsten carbide tools, is being used successfully in many workshops. External, internal, single and multi-start, right or left-hand, parallel or taper threads, also standard or special thread forms, may be cut in most materials, producing accurate and highly finished threads. The single-point carbide tool cuts the thread in a series of passes, which continue automatically until the full depth is reached. This tool is of a similar design to those used in the preceding screwcutting method.

Drilling

The simplest example is that of the masonry drill, which is being manufactured by at least two Australian firms.

Both designs are of the spiral flute type, the claim being that this increases the rate of penetration and prevents packing and "clogging" whilst automatically cleaning the hole.

Sizes of drills produced range from $\frac{1}{8}$" to $1\frac{1}{8}$" diameter.

Materials for which the makers recommend these drills are brick, tile, slate, stone, marble cement, and all masonry and ceramic materials.

Example

200 holes per drill regrind were drilled in one of Melbourne's main buildings, the diameter of the hole being $\frac{3}{4}$", and the depth drilled $2\frac{1}{2}$" in concrete, at an average time of 30 seconds per hole.

"Gun" or "All Depth" Drills

This type of drill is being produced and used by a manufacturer of valve bodies, for drilling holes to an accuracy of 0.0001" to 0.0002" in cast meehanite valve bodies. The drill used is of the solid type (Fig. 8), having one cutting carbide tip, and three wear pads of a straight tungsten carbide grade. The cutting edge is either on centre or up to 0.003" below centre to give a free cutting action.

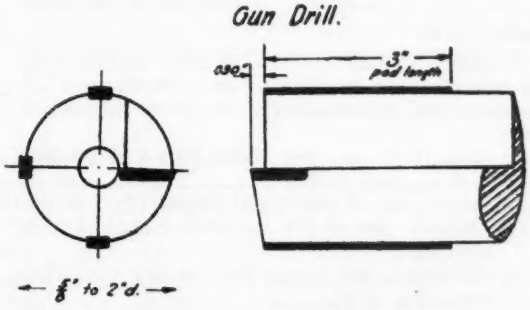

Fig. 8.

Bore diameters of $\frac{5}{8}$" to 2", and lengths of 6" to 13", are drilled direct from the cored hole after a counter-boring operation to obtain seat for wear strips ; the bores may contain from four to 10 port recesses, hence the long wear pads.

Machines used for this operation are either Herbert or Potter & Johnson automatics, with a cutting speed of 230 ft./min. with a feed of .005" to .007" per revolution, and a depth of cut ranging from .015" to .032".

Coolant, which must be thin enough to get into the burnishing area between the workstrips and the work surface, is fed through the bore to wash away the chips formed and act as a lubricant for the wear pads.

Tungsten Carbide Dies

Whilst cemented tungsten carbides are probably best known for their metal cutting characteristics, it was as a material for dies in the wire drawing industry that cemented carbides made their initial appearance.

Dies of this material are almost exclusively used by the Australian wire, bar and tube manufacturers, providing perhaps one of the greater outlets for tungsten carbide. Increases of die life, some 20 to 30 times that of steel dies, are not unusual, due to the inherent resistance to abrasion of the carbide. Die bore finishes are in the region of two to three micro-inches, which assure a high finish being transferred to the work produced. Manufacturers of these dies consider that an increase in output of 25% or more is not unusual.

Carbide heading dies for the high speed production of bolts, screws, and rivets are now superseding steel dies, permitting an increase in production rates of high tensile products by cold forging, as well as providing a more constant blank diameter, which has increased the life of the thread rolls and given a better shape and finish to the threads.

Carbide deep drawing dies are also being used, with an improvement in life of from 20 to 100 times that of comparable steel dies.

The majority of users of carbide dies have, in their own tool rooms, suitable plant for re-servicing and, in some cases, for producing the dies from purchased nibs or blanks.

Press Tools

Tungsten carbide is now being applied with increasing success to blanking and piecing tools for various types of components, its prime advantages being :-

(a) lower tool cost per piece produced (despite higher initial cost) ;
(b) longer life of dies and longer life between regrinds, due to the carbide's ability to resist abrasion ;
(c) freedom from burrs, due to the die edges remaining sharp ;
(d) work hardening materials may be drawn to increased depths due to the high finish obtainable with these dies.

Special grades of carbide having a high resistance to impact are supplied by the manufacturers for these applications. Where possible, mechanical methods of holding the carbide inserts are used, limiting brazing to those cases of absolute need. In these circumstances the braze is kept to a thickness of 0.003" to 0.005". Small punches are made of solid carbide, with a reduction in overall length that is permissible due to the longer life between regrinds, thus providing greater rigidity. Larger punches use carbide mechanically held to a steel shank.

Example 1

A tungsten carbide die set for producing razor blades from strip has now been in use for five years, both die and punch consisting of solid and tipped carbide punches with solid carbide die segments.

Razor blades are produced one per stroke, over 500,000 blades being blanked and pierced before re-lapping of tools. Lapping of tools consists of removing 0.001" to 0.002".

Example 2

Press tools are also being used by a manufacturer of dental equipment, for blanking and piercing of abrasive shellaced backed paper discs, with an increase in die life of several hundred times the life of conventional steel press tools.

Wear-Resisting Applications

Tungsten carbide with its high hardness and wear-resistant properties finds many applications in the textile and other non-metallic industries.

Wear-resistance is difficult to measure since it varies under the different conditions encountered in service. As a general rule a factor of 100 : 1 when compared to steel may be used, this, of course, varying with the grade of tungsten carbide. The straight tungsten carbides with a low cobalt content are the most resistant to that type of wear caused by impinging solids and liquids, although when pick-up is a factor in wearing action against metals the grades containing tungsten titanium are better.

The Turbo-mist Automatic Concentrate Sprayer uses tungsten carbide nozzles, valves and seats. After many tests, tungsten carbide was found to be the most suitable material to use for the spraying of corrosive mixtures, due to its corrosion-resistant properties and resistance to wear and abrasion. This equipment uses seven tungsten carbide disc nozzles, the nozzles having the following dimensions :-

Outside diameter	0.850"/0.870"
Bores	0.040" and 0.050"
Thickness	0.040"/0.045"

In use on this machine are four discs with 0.040" diameter bore, and three discs with 0.050" diameter bore. The unit travels at an approximate speed of $1\frac{1}{2}$ miles per hour working at a pressure of 250 lb. output to give 2.5 gallons per minute, or 300 lb. output for 3 gallons per minute (Imperial gallons). Under average conditions, the nozzles can be expected to last for two or three seasons.

A different wear-resisting application, commonly found in the machine shop, is the use of tungsten carbide rollers and pins, used in conjunction with carbide tools in roller boxes.

Example

A roller box on a seven-year-old Ward 3A Capstan was fitted with a set of carbide rollers and pins for the machining of $1\frac{1}{4}$" diameter bar stock (30/40 ton steel). Cutting speed used was 400 feet per minute, with a 0.010" feed per revolution, depth of cut of 0.070", and a turned length of $2\frac{1}{4}$". Tool life between regrinds was five hours and finish on roller turned diameter 2 micro-inches.

Rollers used on this machine were $\frac{21}{32}$" diameter, $\frac{5}{16}$" wide, with a bore of $\frac{3}{8}$", the pins being $\frac{3}{8}$" diameter by $\frac{3}{4}$" in length.

Steel rollers and pins seldom last more than 400 hours without excessive wear, but the carbide rollers and pins fitted to a Wickman 5-Spindle Automatic showed no measurable wear after 3,000 hours continuous work.

Tungsten Carbide Burrs

Industrial burrs are finding ever increasing application, such as removing burrs from castings and steel forgings, and the finishing of dies.

Manufacturers quote the life for these tungsten carbide burrs to be in excess of 100 times the life of high speed steel burrs. The greatest hazard to this life figure is the possible slowing down of the portable tool, therefore, the driving unit must have a spindle that runs true and be supplied with ample power.

Carbide burrs are also used on jig grinding machines for the finishing of bores.

Example 1

Component: Drill jig hardened to 64 Rockwell C.

Tool: $\frac{1}{4}$" dia. cylindrical shaped, end cutting tungsten carbide burr.

Operation: 14 Drill bush holes to be opened up to a positional tolerance of 0.0005". Hole diameters vary from $\frac{3}{8}$" to $\frac{5}{8}$".

Speed of burr: 60,000 r.p.m.

Depth of cut: To be removed per hole 0.010"

Time taken: For complete operation (14 holes) four hours. By alternative method of grinding, the same operation would take 20 hours.

Example 2

The opening up of a hardened ring gauge to within 0.0001" of roundness, with a maximum of 0.0001" bell, and a surface finish of six micro-inches in the $\frac{3}{8}$" dia. bore.

Dental Burrs from 1.02 mm. to 2.06 mm. diameter are now finding a place in the dentist's instrumentarium, as it has been proved that they cut dental enamel more quickly and evenly, and retain their cutting edges longer than any steel instrument. These carbide burrs are used for the initial opening up, and for external extension of cavities, using the steel burrs for the softer dentine.

Tungsten carbide burrs can be used effectively at a speed as low as 2,000 r.p.m., although recommended speeds are between 3,500 and 6,000 r.p.m.

Rock Drilling

Although the industrial diamond is highly satisfactory for drilling long holes in the hardest rock, it may not be used when it is necessary to drill by percussive methods. Hence, tungsten carbide, with its high impact strength and high resistance to abrasion, has been found an ideal material for use on drill stems for percussive drilling.

As well as manufacturing these drills in Australia, considerable quantities are imported annually.

It was contended at one mine that 10,000 drills were in circulation, of which 1,500 are sent to the surface each week for reservicing — eight to ten regrinds are considered normal for the life of the drill.

Penetration figures are in the region of 300 feet, or an average of 35 feet per regrind per drill at this particular mine.

Post Hole Diggers

Post hole diggers tipped with a rock cutting grade of tungsten carbide, guaranteed to drill 98% of rock, are in use throughout Australia, particularly in the limestone areas of South Australia, where it is virtually impossible to sink holes manually.

The unit relies upon the weight of the tractor to which it is attached, to force the rotating auger into the ground. Tungsten carbide tips are brazed on to steel shanks to form the cutting edges, and are detachable for ease in re-servicing.

Example

A hole 9" diameter, 20" deep is drilled into solid limestone in five minutes, at a speed of 45 r.p.m.

Speeds on this digger are adjustable: 45 r.p.m. is recommended for stone, and 120 r.p.m. for earth and clay.

COMPARATIVE SPEEDS FOR ROTARY BURRS

Burr Head dia.	STEEL AND CAST IRON		STAINLESS STEEL	
	Carbide Burr r.p.m.	*H.S.S. Burr* r.p.m.	*Carbide Burr* r.p.m.	*H.S.S. Burr* r.p.m.
$\frac{1}{4}$"	22,000 to 60,000	5,000 to 8,000	33,000	13,000 to 19,000
$\frac{3}{8}$"	20,000 to 50,000	3,000 to 5,000	29,000	9,000 to 13,000
$\frac{1}{2}$"	10,000 to 30,000	3,000 to 4,000	27,500	7,000 to 10,000
$\frac{5}{8}$"	10,000 to 20,000	2,000 to 3,000	26,000	5,000 to 7,000

Cutting of Coal

Chain Coal Cutter Picks

The efficiency of any cutting machine, whether in the factory or at the coal face, depends upon the tools used. For this reason, considerable research has been undertaken to perfect a grade of tungsten carbide suitable for this application.

The carbide tips are brazed to shanks of heat-treated high tensile forged steel. These cutter picks have proved in a variety of coal seams, over long periods, that yardages many times greater than forged or hand-welded types are common, with the tungsten carbide tipped coal pick.

Drilling of Coal

In the early days of coal drilling, output was limited by the performance of the tool steel drill bit, but since the introduction of the carbide tipped drilling bit, the practice of drilling in stone and coal has been revolutionised. Special grades of tungsten carbide have been perfected to withstand the arduous abrasive action as the drill rotates through the coal. The bits are used wet or dry, depending upon the material being drilled. On normal coal drilling the design of the cutter produces coarse particles, but for certain classes of stone which produce fine dust the wet method is suggested.

Carbon Dioxide (CO_2) Cooling

This principle of cooling has advanced no further than the experimental stage in Australia. Several firms have conducted cutting tests which, although not conclusive, due to the short runs taken, have proved that higher speeds and feed rates may be used with increased tool life, particularly in the case of heat resisting steel or when bulk metal must be removed.

In conclusion, it is obvious that the advance of the tungsten carbide industry is dependent upon the so-called secondary industry of Australia, and until the demand for any new application is sufficient for the installation of special plant to produce economically, we must import certain special tools.

REFERENCES

(1). Honeycombe & Greenwood, A.I.M.M. pp 250-270, 128, 1942.

(2). Standards Association of Australia.

(3). H. W. Ward & Co. Ltd. Reprint British Machine Tool Engineering.

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WORK MEASUREMENT

and its uses for

Management Control

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As an Industrial Management Consultant with Urwick, Orr & Partners Ltd., Mr. Hewett has had experience in a range of industries, including wood processing, textiles, brass foundry and the automobile trade.

After studies at Loughborough College, Northampton Polytechnic and Regent Street Polytechnic, he obtained National and Higher National Certificates. A mechanical engineering apprenticeship at Simms Motor Units Ltd., London, was followed by experience with several firms in the production of fuel injection equipment, telephones, radio and radar, in the successive positions of Inspector, Jig and Tool Designer, Production Investigator and Assistant Production Controller.

Mr. Hewett joined the Research Department of The Institution of Production Engineers under the late Dr. G. Schlesinger, and when the Department was expanded into the Production Engineering Research Association of Great Britain, he was Engineer Superintendent and, later, Senior Investigator responsible for metal cutting research.

He has served as a member of the London Graduate Section Committee, and has had published work on "Production Service — Its Measurement and Efficiency"; "Measurement of Manufacturing Performance"; and "Balance in Flow Production". The Paper published here was presented to the Leicester Section of the Institution on 27th September, 1957.

IN the current surge of capital investment which manifests itself in the installation of faster and bigger machines to offset the constantly rising cost of manual labour, the reports of these improvements only state part of the story. The output of the new equipment always shows a big improvement over whatever prevailed previously, but there is no indication of how effectively the previous equipment was being used.

When capital was scarce people used to say " It is not what you can do with that counts, but what you can do without." It is a sound rule to achieve the greatest possible efficiency with the existing machines and labour before indulging in new equipment. This does not deny that new equipment will yield an economic gain; it just ensures that money is not spent unwisely.

The first essential is a measure of productivity, so that the efficiency of the existing equipment and labour may be known.

" Productivity " in this context means " productivity of labour " expressed as a ratio. " It is the rate of input in the form of production resources, to output, in the form of production—goods and services—obtained for the consumption of those resources." [1] This applies to the mammoth flow-line or the jobbing shop with equal truth. The following sections of this Paper consider the subject with particular respect to the batch production machine-shop using standard machine tools to produce a range of components. This type of producing unit is still the backbone of the engineering trade in both this country and the United States, and high labour productivity is more difficult to achieve under batch production conditions than any other, and is the more worthy of attention for this reason.

For a productivity of labour ratio, the " input of production resources " is the number of hours the workers are available for work. The " output in the form of production, goods and services " can be expressed in several ways, if one factory only is being considered and it is making only one or two things, say a range of gas cookers, or two sizes of paper clips; the number of these things divided by the hours worked may, for some purposes, be a good sensible simple unit.

Unfortunately most works make a wide range of several products, and possibly only parts of some products. In the case of the machine-shop a " product unit " is very unsuitable. The best, in fact, the only worthwhile unit, is undoubtedly the " labour content" of the work. How to measure the time for the job is a rather technical proceeding, the details of which vary widely, and about which more is written later in this Paper.

Assuming that accurate information is available on the labour content of each job, and that this can be related to the clock hours worked, this is the gauge by which management can measure the performance.

To the executives of a factory which can fall behind on its delivery dates and not lose orders, obtain money easily for more modern plant and more technical staff, and with all this pay its workers a high wage, unrelated to their production, the remainder of this Paper is better unread. To those not so fortunate, or aware that they are changing from such a position, the contents of this Paper may refresh their memory on such matters as setting equitable work standards for incentive payment, using the work standards for measuring shop and machine group efficiencies, and accepting as the criterion of their own performance the same objective measure which they apply to the machine operator.

Build-up of standard times

A. *Work Study*

This article is not intended to be a treatise on work measurement, but since there is more than one way of using the result of work measurement, it is advisable to state the method used when compiling the standard times used in the examples shown in this Paper. References are given to more detailed description of work study in publications dealing specifically with this subject.

1. *Work study*

In the course of observing an operation, all the elements of work involved are noted and " fly-back " stop watch time recorded for each of them.[2]

In operations which have combined manual and machine work, such as in machine-tool operating, it is essential to separate the manually controlled work from machine-controlled work, for example:—

Pick up piece and place in chuck and start machine	(Manual)
Machine operating ...	Machine-controlled
Stop machine, gauge part and start machine ...	(Manual)
Machine operating ...	Machine-controlled
Stop machine, remove piece from chuck and lay aside	(Manual)

There is no limit to how long the operator may take to do his part of the operation, but the machine time should be consistent on every piece, assuming no alterations to speeds and feeds.

Because of human frailty a " rating " of the manual work elements is necessary [3] and [4]. " Rating is that process during which a time-study engineer compares the performance of the operator under observation with the observer's own concept of proper performance." [5]

In this matter of judgement, the basis of the rating scale used in this respect is as follows:—

60 minutes' work per hour (60 P.I.) is the " normal " rate such as may be expected from a worker on daywork.

80 minutes' work per hour (80 P.I.) is a reasonable rate such as should be found in a brisk worker concerned to earn a good bonus.

Between these rates, 65, 70 and 75 minutes per hour can be judged with fair accuracy. Ratings below 60, say down to 40, and above 80, say up to 100, become progressively more difficult to judge if only because one sees fewer of these.

After rating a series of manual performances the observed and recorded times have to be normalised, i.e., brought to a common denominator of 60 minutes per hour:

Manual work elements per piece

Element	*Average Observed Time*	*Average Rating*	*Normal Minutes*
Put down and pick up work	0.37 min.	70	$0.37 \times \frac{70}{60} = 0.430$ n. min.
load and unload chuck	0.46 min.	75	$0.46 \times \frac{75}{60} = 0.570$ n. min.
Gauge work	0.12 min.	60	$0.12 \times \frac{60}{60} = 0.12$ n. min.
Total observed time	0.95 clock min.		1.12 normal min.

Before these times can be added to the machine running time they must be converted to the same rating, i.e., machine time is always taken as 80 P.I. which is the rate of work expected throughout the job when the operator is really trying to earn bonus.

Convert normal minutes to 80 P.I.

$1.12 \times \frac{60}{80} = 0.84$ *clock* min. at 80 P.I.

Add machine running time, say,	3.0	,, actual time
	3.84	,, at 80 P.I.
Allow Relaxation time, say 10%	.38	
	4.22	

Convert to 60 P.I. to obtain " Work Standard " per piece $4.220 \times \frac{80}{60} = 5.62$ standard minutes.

Now, the calculations for the operator's performance under specified conditions are as follows:—

(i) If he continues to work at the same rate as he did during observation, i.e., 0.95 min. manual work + 3.0 min. machine time per piece: Performance (P.I.) will be:—

$$\frac{\text{Work Standard}}{\text{Time taken}} = \frac{5.62 \text{ std. min.}}{0.95 + 3.0} \times 60 \text{ min. per hr.}$$

$$= 85 \text{ P.I.} \quad \textit{while he is working}$$

If the operator takes his full 10% relaxation allowance he will achieve approximately 78 P.I. over the whole week.

(ii) If he improves his performance and works at the "expected" rate of 80 P.I. the time taken per piece will be:—

$$5.62 \text{ std. min.} \times \frac{60}{80} = 4.20 \text{ min. per piece over the whole week.}$$

If the operator has taken his full 10% relaxation allowance his time per piece *while working* has been:—

	4.20
Less 10%	.42
min. per piece	3.78

His performance while working was $\frac{5.62 \text{ std. min.} \times 60}{3.78 \text{ min.}}$

$$= 89 \text{ P.I.}$$

2. *Synthetic time values*

The treatment outlined above is the simplest case where a standard is needed for one specific job. To carry out this procedure for all the permutations and combinations of element times which can occur on such work as machine tool operating, requires a great amount of study time. To avoid this "synthetic" times are used; these are tables of predetermined time values. They are created by studying a representative number of operations for the range of work normally encountered on a particular machine and then plotting the results graphically, or using simple arithmetic treatment as a means of preparing sets of values to cover all the expected range of work elements.

From these synthetic values work standards can be quickly set for operations within the range covered by the tables.

The practicability of this method depends upon the ability to recognise fixed and variable elements, followed by good time study work, to obtain a range of values of those features which matter in the particular process.

Almost any production machine tool can be time-studied and have synthetic time values prepared which will be valid for all operations normally produced. When centre lathes are used for making one or two pieces with the maximum work done at each pick-up they are beyond synthetic application, as it is difficult to foresee the sequence of work, and the number of cuts involved. However, if these machines are used in a production fashion by semi-skilled workers, i.e., the work is picked up several times and only one or two diameters or faces dealt with each time, then synthetic data can be easily prepared.

In the writer's personal experience, machines which are now operating on work standards set from synthetic time data include:—

Capstans
Turret lathes
Millers, all sizes
Key-seating and slotting
Broaching
Grinding—external, internal, centreless, spline and gear
Gear cutting and tooth rounding
Drills—light, pillar and radial
Fettling castings on grinding wheels and in the vice by filing
Deburring machined work, such as gear teeth
Power presses
Press brakes
Guillotining
Nibbling.

When applying synthetic values hardly any single standard is exactly right, but over several jobs the *average* is correct. The degree of inaccuracy of any one standard depends upon the degree of detail in which the synthetics have been prepared. A balance has to be struck between synthetic tables so detailed and involved that they lose their purpose, and tables including under one standard time, elements so variable as to make the results wildly inaccurate.

A general guide in this respect is that the increments in the tables of values should be 10% to 20% on the previous value. This is subject to any definite increase forced by some feature of the process, such as "moving up to the next pulley," or putting in the next available gear.

Element definition is a prime requisite in time studies which are to be used in preparing synthetic time data. Definition in this context means defining not only the work done but the precise starting and finishing points. For example, in radial drilling work, "move drill from hole to hole" is misleading without specifying that the element starts when the drill point leaves the first hole or bush, and ends when the drill point contacts the work for the second hole.

The terms "constant" and "variable" elements also require definition, e.g., a "constant" is an element for which the standard time allowance should be always the same, for a specified set of conditions.

A "variable" is an element for which the standard time allowance should change to compensate for variations in effort required according to a range in the dimensions of the product or equipment.[6]

In machine tool operation the manual elements involved in manipulating the jigs or fixtures to load and unload the work, or swing a turret, or wind a traverse handle, are comparatively simple to time and record. The more important part of the operating is the cutting elements. When the correct speed and feed are known the arithmetic is very simple; the problem of what speed and feed are correct is far more difficult. Fortunately, most speed and feed changes are in definite and substantial increments, according to the pulleys or gears available, and reference to

previously studied similar jobs, or data collected and suitably referenced in the Time Study Department, will avoid gross errors due to the time study observer's lack of knowledge of the process, or the uncertainties which prevail when even experienced engineers meet an unusual operation.

It is a good general rule that unless speed and feed have been specified by a Planning Department on the layout sheet, the average shop setter or operator will run slower than the optimum. The setter or operator is concerned to get a full run or batch of parts without having to regrind or change tools. To ensure this he errs on the side of slow running, and it is not unusual to find him " erring on the slow side " even more than usual when he knows the time study man has still to see the job. The time study engineer is always told the speeds and feeds are correct, only in the same way as some people are more equal than others, so some speeds and feeds are more correct than others.

In the following section are shown some specific examples of work standards, especially selected to illustrate the two basic methods described above, i.e.,

(i) Work Standards for specific jobs, based on work study of the particular job.

(ii) Work Standards based on synthetic values built up from work study of the range of jobs expected.

B. Examples of Work Standards

1. *Specific Jobs*

Under this heading are shown two " stores type " jobs. Although these two examples involve fairly similar work elements, they are shown here to illustrate two different methods of building the time study into a work standard to be used for incentive payment.

These examples have been particularly selected, since stores work is frequently passed over as being too variable for application of incentive payment for direct work.

(a) Unload goods from vehicle, transport and stack.

(i) *Description of work*

A. Load trolley. 2 men.
(Work done at delivery vehicle)
Receive goods from tail-board of road vehicle or railway truck, usually 8 or 10 items per trolley load of 10 cwt.
Push loaded trolley away from working area (usually 6 ft). Pull empty trolley into position for loading (usually 6 ft).

B. Unload. 2 men. Work done at stacking point.
Receive goods on trolley (usually 8 or 10 items per trolley).
Stack goods safely and neatly. Push empty trolley away (usually 6 ft). Pull loaded trolley into position.

C. Transport. 1 man. (Moving goods between delivery point and stacking point.)
Push loaded trolley from unloading bay to stacking point anywhere in the stores. Return with empty trolley.

D. Auxiliary work.
At commencement of job find and take empty trolleys to unloading bay. At completion of job return all trolleys to storage point.
Receive Advice Note and take to office.
Find and set dunnage as required.
Keep working area clean and sweep up on completion of job.
Stack all goods neatly and square to gangway.

(ii) *Element Times*

Work Unit. 1 ton of goods (usually 2 loads).			
Description	*Team*	*Min. at 80 P.I. Min.*	*Synchronising min. for unbalanced job*
load trolley	2 men	7.0 ms or 14 operator min.	6 min.
transport via lift	1 man	9.0 ms or 9 operator min.	1 min.
unload trolleys & stack	2 men	10.0 ms or 20 operator min.	—
Total	5 men	43	7

Team of 5 men cycle-time = 10.0 clock min. at 80 P.I. per ton

Total operator minutes at 80 P.I. $= 10 \times 5 = 50$ min.

Total operator minutes at 60 P.I. $= 50 \times \frac{80}{60} = 67$ min.

Relaxation of 10% 6.7 min.

73.7 std. min. per ton

Issued value 74 sms per ton
or
Work Standard at 0.80 ton per hour.

(b) Unload cartons, transport and stack.

(i) *Description of Work*
Unloading cartons from trailer transport on flat truck to stack. Stack by hand.

(ii) *Operators*
Team of 5 men
2 off-loaders on trailer.
1 transport man, to push loaded truck to stack and push empty truck back to trailer.
2 stackers, to unload trucks and stack cartons.

(iii) *Element Times*

Description	*Time per carton Min. at 80 P.I.*
Off-load cartons from trailer to flat truck	0.094
Move trolley to stack	0.040
Stack cartons from trolley ...	0.112
Position trolley	0.014
Place dunnage in position where required	.033
	.293
Time at 60 P.I.	.390
Relaxation 10%	.039
	0.429 sms

Issued value 0.430 sms per carton
or
Work Standard of 140 cartons per hour.

2. *Variable Jobs*

Under this heading the examples have been chosen to illustrate the use of synthetic time data. The work standards shown cover the range of work involved in processes of floor scrubbing, broaching, and internal and external grinding.

(a) Floor cleaning with electric floor scrubber.

The work standard is for an average 100 sq. ft. area with an appropriate "preparation and clear-up" allowance.

In operation, the main floor areas of the factory are measured from a floor plan and a standard time set according to the area.

The work done by a night shift cleaner is checked in the morning by the foreman of the cleaners, and the man's incentive earnings computed.

Work standard for floor cleaning with electric floor scrubber.

Time to clean 100 sq. ft. is	
Scrub with machine	11.5 min.
Sweep floor, collect swarf into wheelbarrow	3.3 min.
	14.8
Preparation and clean-up time is 20.02 min. once per 4 hr. or	
$\frac{20}{240}$ = 8% Add 8%	1.2 min.
	16.0 min.
Relax 15% ...	2.4
	18.4 sms per 100 sq. ft.
Expected production time at 80 P.I.	13.8 clock min. per 100 sq. ft.

(b) Broaching.

The standards shown are for a particular type of broach engaged on key-way and spline broaching on a range of components.

It will be seen that straightforward work study results supply the data for the manual work, and this is constant over the range of work handled.

The machine controlled time depends upon the length of broach.

The sum of the machine travel time (forward and return stroke) added to the manual time gives the expected floor to floor time per piece. When relaxation of 10% is added and the expected 80 P.I. converted to time at 60 P.I. a "standard time" is obtained.

Standard Time on Broaching

Manual Time	*Min.*
Pick up from stillage to bench	0.12
Load on to broach	0.30
Fit broach into machine ...	0.37
Remove broach	0.10
Unload work-piece to stillage ...	0.15
	1.04 at 60 P.I.
or	0.78 min. at 80 P.I.

Machine Time

Length of Broach	*Inches* 0 to 15	15.1 to 20	20.1 to 25	25.1 to 30	30.1 to 35	35.1 to 40	40.1 to 45
Forward Stroke at 40 ins./min.	0.36	0.50	.62	0.75	0.87	1.00	1.12
Return Stroke at 120 ins./min.	0.12	.17	.20	.25	.29	.33	.37
TOTAL MACHINE TIME	0.48	0.67	.82	1.00	1.16	1.33	1.49
TOTAL MANUAL TIME	.78	.78	.78	.78	.78	.78	.78
EXPECTED TIME at 80 P.I.	1.16	1.45	1.60	1.78	1.94	2.11	2.27
10% Relax	.12	.14	.16	.18	.19	.21	.23
STD. TIME (60 P.I.) ...	1.28	1.59	1.76	1.96	2.13	2.32	2.50
	1.70	2.10	2.35	2.60	2.84	3.10	3.30

(c) Internal and external grinding.

Production engineering purists may shudder to see so involved a process as grinding reduced to standard times by such simple and arbitrary decisions as shown below. However, the table shown applies in a shop with components ranging from a few ounces up to 40 lb weight, with bores and outside diameters from $\frac{1}{4}$ in. dia. to 10 in. dia. and $\frac{1}{4}$ in. to 6 in. long; tolerances range from 0.00025 in. upwards.

Certain very difficult jobs have to be time studied but not more than 3 jobs in 100 prove to be outside the synthetic range.

The manual elements involved in every *grinding* operation have been added to the cutting times for specific conditions. Additional manual time is given where appropriate, e.g., extra gauging time, "trueing" work to a dial gauge, etc., fit and remove splash guards when necessary, grind steady diameter and measure, etc.

It will be seen that the standard time record for external work has columns for up to 4 parts, i.e., four times in and out of the machine. This is necessary for cluster gears, etc., with several diameters and shoulders to be ground.

INTERNAL GRINDING

Rates of Cutting

Based on always taking out 0.012 in. stock on diameter with a feed per pass depending upon size of bore, rigidity of spindle and size of wheel.

Feed Per Pass

Holes below ½ in. dia.	0.0001 in. per pass
Holes ½ in. to 1¼ in. dia.	0.00015 in. per pass
Holes 1¼ in. and over	0.0002 in. per pass

Number of Passes per Bore and Cutting Time

Passes per min.	60	40	20
.012 in. / .0001 = 120 passes	2 min.	3 min.	6 min.
.012 in. / .00015 = 80 passes	1.3 min.	2 min.	4 min.
.012 in. / .0002 in. = 60 passes	1.0 min.	1.5 min.	3 min.

Cutting Time at Specified Passes per Minute

	Below ½ in. dia. Min.	*½ in. to 1¼ in. dia.* Min.	*Over 1¼ in. dia.* Min.
Hardened work normal 40 passes per min.	3.00	2.00	1.50
Soft work normal 60 passes per min.	2.00	1.30	1.00
Long bores and delicate work 20 passes per min.	6.00	4.00	3.00

Manual Work Single Elements

	Spring Chuck Min.	*Fixture or Arbor* Min.	
Load and unload ...	0.70	1.00	
	easy	med.	difficult
Clock true	0.25	0.50	1.00
Gauge	1 *occ.*	2 *occ.*	
Using plug gauge ...	0.18	0.36	
Using 2 plug gauges ...	0.30	0.60	

Combined Manual Elements

	Spring Chuck	*Fixture or Arbor*	
Load, unload and normal gauge (2 occ.)	1.06	1.36	
	say	1.40	min.

Combined Manual and Machine Elements

		Below ½ in. dia.	*½ in. to 1¼ in. dia.*	*Over 1¼ in. dia.*
Hardened work 40 passes per min.	spring chuck	4.00	3.00	2.50
	fixture	4.40	3.40	2.90
Soft work 60 passes per min.	spring chuck	3.00	2.30	2.00
	fixture	3.40	2.70	2.40
Long bores and delicate work 20 passes per min.	spring chuck	7.00	5.00	4.00
	fixture	7.40	5.40	4.40

Record Sheet

INTERNAL GRIND

DESCRIPTION DATE .....

DESCRIPTION OF OP. MAT.....

	Part 1	Part 2	Part 3	Part 4	
Method of Load Size of Bore Length of Bore Type of Work Extras F. to F. time at 80 P.I.					
TOTAL MACHINE TIME					
ALLOWANCE					
STANDARD TIME					

Part No.	Op. No.	Description of Part	S. MS	Rate

EXTERNAL GRINDERS

Grinding machine cutting times plunge grind only, based on 60 f.p.m. work speed.

0.0005 in. stock removal from dia. of work per rev.

.015 in. stock removal from dia.

To the cutting time is added essential manual work, e.g.,

position wheel 0.156 s.ms	=	0.106 clock min. at 80 P.I.
withdraw wheel 0.068 s.ms.	=	.05
		0.156
say,		0.150 clock min. at 80 P.I.
Measure dia. with micrometer		0.180
		0.330

Total manual time to be incorporated with plunge grinding 0.330 clock min. at 80 P.I.

Diameter (Inches)	Plunge cut only — Tolerance (inches)				Plunge cut plus essential manual work — Tolerance (inches)			
	Up to .0005	.0005 to .0010	.001 to .003	.003 and over	Up to .0005	.0005 to .0010	.001 to .003	.003 and over
Up to 1	.26	.22	.21	.20	.59	.55	.54	.53
1.1 to 2	.54	.42	.40	.32	.87	.75	.73	.65
2.1 to 3	.78	.64	.58	.50	1.11	.97	.91	.83
3.1 to 4	1.04	.86	.78	.70	1.37	1.19	1.11	1.03
4.1 to 5	1.30	1.10	1.00	.83	1.63	1.43	1.33	1.16
5.1 to 6	1.58	1.30	1.18	1.02	1.91	1.63	1.51	1.35
6.1 to 7	1.84	1.60	1.40	1.22	2.17	1.93	1.73	1.55
7.1 to 8	2.10	1.76	1.57	1.40	2.43	2.09	1.90	1.73

Extra work—grind small face to clean up 0.17 min.

grind face to size 0.80 min.

grind large face to size 0.90 min.

RECORD SHEET

EXTERNAL GRINDING

Description of Operation

Date.....

Mat.....

	Easy	Med.	Diff.	Part 1	Part 2	Part 3	Part 4
L. and Unl. and fit dog	.42	.48	.80				
Mandrel	.27	.54	.80				
Clean and grease centres	.13 grease centres		.08				
Gauge: micrometer 0–1 in.	.12	1–2 in. caliper or gap .18	.12				
Fit and remove splash guard	.25						
Grind steady dia. and mic.	1.00						
Position and clear wheel	0.10						
TOTAL MANUAL TIME							
Machine Cutting Time — Dia. / Lth. / Tol.							
TOTAL MACHINE TIME							
ALLOWANCE							
STANDARD TIME							

Part No.	Op. No.	Description of Part	S.MS.	Rate

Use of standard time data

A. *Labour Performance Record*

The prime use of standard time is for incentive payment. When this has been done it is comparatively easy to extend the data, which has been accumulated in the course of wages preparation, into some form of Labour Performance Record. The basic facts needed for this purpose are shown on a representative type of Labour Performance Sheet (Appendix 1).

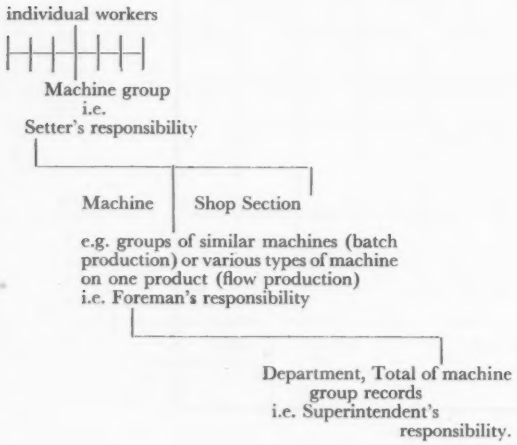
The data to be entered on this chart is as follows:—

Col. No.	*Heading*	*Description of Data*
1	Week ended	
2	Minutes of work "measured"	Standard minutes of work.
3	Minutes of work "unmeasured"	Minutes of work done, but paid for as "clock time"; useful work was done, but no standard time was established, e.g., prototype jobs, repair work and " 1 off " jobs not likely to be repeated. This should not exceed 10% of the clock hours worked.
4	Minutes of work total	The sum of " 2 " and " 3 " shows the total minutes of useful and *saleable* work gained.
5	Clock hours	Clock hours worked in the period under review.
6	Performance Index "measured work"	$\frac{\text{Col. 4}}{\text{Col. 5}} = \frac{\text{Minutes of useful \& saleable work}}{\text{clock hours}}$
7	Performance Index "Extra work"	$\frac{\text{Co. 14}}{\text{Co. 5}} \quad \frac{\text{Total excess time}}{\text{clock hours}}$
8	Performance Index " Paid "	$\frac{\text{Col. 4} + \text{Col. 14}}{\text{Col. 5}} \quad \frac{\text{Total minutes paid}}{\text{clock hours}}$

Excess Time

9	Setting min.	Minutes allowed to setting.
10	Extra min.	Minutes allowed for extra work, such as excess metal on castings, " hard inclusions," faulty machine or tackle.
11	Waiting min.	Minutes allowed for waiting time.
12	Scrap min.	Minutes allowed and paid for on which work was scrapped, but not due to operator's bad work, e.g., faulty castings, or work machined wrongly on previous operations.
13	Reclaim min.	Minutes allowed for work on jobs previously scrapped, but being reclaimed by special operations. This is *not* payment for the operator reclaiming his own faulty work. He does that without any extra time or extra payment.
14	Total min.	Sum of columns 9 to 13 inclusive.
15	Cost of excess time	Money paid for excess time.
16	Rate variance	The net figure of "extra" and "less" paid for work done by a different grade of labour than planned. e.g., men on a job planned for women, such as putting a light capstan job on to a centre lathe, or an " auto " job being done on a capstan.
17	Total excess cost.	Sums of columns 15 and 16.
18	Excess cost per min.	$\frac{\text{Col. 17}}{\text{Col. 4}} = \frac{\text{Total excess cost}}{\text{Minutes of work done.}}$ This figure is the amount to be added to the " rate per std. min." to obtain a total labour cost per std. min. excluding cost-of-living or other bonuses.

From the individual weekly work sheets of operators, or whatever records are kept of workers' production, labour performance data can be built up progressively to give a performance figure for the sections controlled by supervisors from the lowest chargehand responsible for a line of machines, progressively through foremen, superintendents and managers. In each case the superior is presented with a weekly report of labour performance of the section for which he is responsible, thus:—



B. *Use of Performance Records*

1. *Management control*

Weekly figures enable sudden changes in performance index or excess cost to be easily traced.

It is reasonable to issue the Labour Performance records to the machine-shop supervisor, instructing him to make the figures for individual machine groups available to the setters responsible for them.

Unless supervisor's weekly bonuses are based on the result shown on the Labour Performance sheet (as discussed below) their interest in the weekly figures will be very slight. In fact, they will probably profess not to understand them. However, if their bonus depends upon the figures they will astound one by their grasp of the theory and practice of Labour Performance control when explaining why the figures shown are not fair in their particular case, and how they should be allowed something extra for a fall in performance which is not within their control.

2. *Supervisor's bonuses*

Labour supervisors can, and should, be paid a bonus based on the performance index of their machine group or department. It is essential to pay the bonus on the performance index for " measured " work, excluding any minutes spent on setting, waiting time, scrap payment, etc. This encourages the supervisor to concentrate on producing the maximum amount of " useful " work.

When excess minutes are included in calculation of a supervisor's bonus he has a vested interest in excess cost. It may well be that, sometimes, extra setting and other excesses are *not* the supervisor's fault and may cause him extra work and worry, concluding with receipt of a lower bonus for his pains. This situation is unfortunate, but any relaxing of the terms of bonus payments in consideration of the facts is a kindness which is invariably misunderstood, and is always followed by further requests for concessions on the weakest and most impossible reasons.

3. *Machine loading data*

Only by knowing the performance index of a section is it possible to plan a machine forward load. When a proposed load in standard minutes has been prepared, the total standard minutes divided by the measured work performance index gives the number of clock hours the machines will be occupied on the proposed machine load.

E.g., if the proposed machine load for a particular machine group is, say, 8000 sms per week, and the Labour Performance sheet for a representative recent period shows say:—

	Performance Index	
Measured work	Extra Work	Paid
65 P.I.	15 P.I.	80 P.I.

the proposed load will require:—
8000 sms per week

65 sms measured work obtained per clock hour.
= 123 machine hours per week.

Similarly, if the extra time shown by the performance index figures could be improved by eliminating all extra work, and performance index is equal to the pay index, thus:—

	Performance Index	
Measured Work	Extra Work	Paid
80 P.I.	Nil.	80 P.I.

then the proposed load would require:—

8000 sms

80 sms measured work obtained per clock hour.
= 100 machine hours per week.

These figures given above as an example, i.e., 65 P.I. on measured work, are fairly representative of a machine shop on batch production of medium size work. Such a shop can be brought to 80 P.I., i.e., 23% increase in production by longer runs and elimination of extra work. An improvement of this order, say 15% to 25%, is obtainable in many batch production shops, simply by better planning of work and better production control.

Machine loading can be divided into two main groups

(i) Programme of planned load.

(ii) Current load, or running load.

Programme load has to be built up from the standard time of each operation on each component comprising the finished product. This can only be done where standard times have been developed for all processes. The programme load is most suitable if built up in the manner in which the product is built up, i.e., components listed and their standard time combined into sub-assembly total times; these can then be added to give main assembly times. By this means, changes in production method or the combination of different sub-assemblies to make the main assemblies can be taken into account with the minimum adjustment to the programme load data.

A programme load only needs to be prepared when major changes in manufacturing are envisaged. It will then provide a reasonably accurate guide to the changes in plant and labour utilisation which will result when the envisaged manufacturing changes take place.

A current load is a weekly record of standard minutes " put into " a department, compared with the standard minutes completed in the same week. This provides a regular warning of overload and underload on machine groups. This problem is very acute on batch production machine shops with a wide range of components and a wide range of machine types. For example, a batch of 100 gears may involve 1,000 standard minutes of capstan or auto work, but for gear cutting this could be 3,000 standard minutes of work and involve no drilling or milling. Since work issues are most commonly made to keep stock levels correct or to suit specific customer's orders, the balance of work between sections can be a critical factor in determining machine-shop efficiency.

The Labour Performance Sheet referred to earlier provides a precise weekly record of work completed by each machine group. It is therefore only necessary to total the standard times of the quantities of work issued to have a reliable guide to the balance of work on hand.

Careful control of shop load produces the following benefits:—

(i) Reduction in time taken between issue of raw material and receipt of finished components.
(ii) Reduction in essential stock levels because of quicker processing of work.
(iii) Reduction of work-in-progress which means:—
less capital in work-in-progress
less floor space wasted in material storage
less pieces of paper recording work-in-progress
less difficulty in stock-taking.

C. Standard Times and Wages Payment

The general method of wages payment in the engineering trade is built up thus:—

Cost of living award	22d. per hour
Basic wage	18d. per hour

The figures shown are for skilled men. Semi-skilled, unskilled, female and juvenile workers are paid proportionately less, but to the same pattern of payment.

Since the skilled man expects to earn considerably more than this basic wage, the realistic figure to be considered when establishing payment for standard time is that which has to be paid to retain, and if possible attract, the required grade of man in that particular district.

After deciding what is the acceptable rate in pence per hour for the *average* man, it is necessary to establish how many standard minutes per hour the average man will achieve. If the work standards are correctly set, and the shop efficiency is reasonable, an average performance index of 75 to 80 P.I. should be maintained.

On this basis the rate of payment per standard minute will be:—

$$\frac{\text{Rate per hour to retain and attract required grade of operator}}{\text{75 std. min. per hour.}}$$

If the rate per hour is say " double time " for a skilled man (1s. 6d. rate) then the rate per standard minute will be:—

$$\frac{\text{1s. 6d.} \times 200\%}{\text{75 std. min.}} = \text{0.48d. per standard minute.}$$

Assuming correctly set work standards, any long-term fall in shop operating efficiency will cause a fall in the overall performance index. If this happens, a higher rate per standard minute has to be paid to retain the same grade of labour. This extra expense is part of the price to be paid for the luxury of inefficiency.

The comparatively simple explanation given above to arrive at " how much to pay " is given as an affirmation of the basic facts of wages for work done, since often an operator's wages are made up of so many bonuses, lieu rates, merit rates, " shop averages " etc., that only the wages clerk understands it.

The rate per standard minute given above is for work on standard time, measured work for which the standard was set in advance of, or during the course of, the job; not calculated afterwards on a basis of " What do we have to give him to keep him quiet? "

For unmeasured work, or time covered work for which a work standard could not be set, a lower rate should prevail. This is always difficult to apply, as the operator's argument is, " I do not want daywork, at a lower rate. If you cannot give me measured work, I want the average rate which I can earn on measured work." If an appropriate standard time cannot be set, and unmeasured work is unavoidable, then a careful record of time spent on the job should be made, preferably clocking on and off, and a rate per clock minute paid, which yields an hourly rate less than that earned on standard time.

It is unfortunate that in many cases the unmeasured work on special jobs, repair work, prototypes, etc., has to be done by the best operators. This makes it doubly important to keep such work to a minimum, erring on the generous side, rather than have unmeasured work done in a bad spirit.

In an " average " batch production machine shop, unmeasured work should not exceed 10% of the clock hours worked.

Waiting time has to be suffered on occasions and should be paid for at basic rate plus 27½% (in accordance with Union Agreements).

Wages paid as " pence per standard minute " provide a simple means of adjustment in the event of changes due to wages awards. Only the final computa-

tion of extending standard minutes by rate is affected. All factors and production records are expressed in standard minutes only. This can prove a great advantage where the " metal plate " type of printing is used for piece-work and other documents.

D. Standard Times for Cost Purposes

On a piece-work system the basic standard labour cost of the parts is the sum of the prices for each machining or assembly operation. This is true of parts produced on a standard time system; the standard minutes extended at the rate paid per standard minute on each operation, when totalled, give a standard labour cost per piece.

Assessing the *excess* labour cost over and above the basic standard is an essential feature of costing which is not difficult to do on piece-work prices, the usual method being to spread an average " overall " excess labour cost, expressing this as a percentage of the direct standard labour cost. This is reasonably satisfactory for overall product costs, but is inaccurate and can be very misleading when comparisons are being made of labour costs of made-in and sub-contracted work.

On a standard time system using Labour Performance Records as described on pages 111/112, the excess labour cost for each machine group is shown weekly. This enables a precise comparison to be made of the relative labour costs of different methods of manufacture within the works, and can be used when comparing sub-contract proposals.

There is also a weekly figure of overall excess cost per standard minute which can be used for costing purposes. It is sometimes practical to use machine group excess costs when building up product labour costs, but if a great variety of machined parts is involved, an overall excess labour cost per standard minute is the most satisfactory method.

Some managements have a strange yearning for what they call " actual costs." An actual cost is a nice thing to know if you like shutting gates when the horses have gone. An actual cost must be an historical cost and this cannot provide a guide to management action except when the next batch of the same thing is made, by which time no one remembers what was wrong the first time.

An actual cost is also a product cost and this is no guide to factory control; also it contains the resultant of all the factors prevailing when the job was done, price or time per piece, grade of labour employed, size of the batch, section efficiency, all are jumbled up in a set of figures received too late for effective analysis.

Standard costs contain no such limitations. They only demand an act of faith in accepting the accuracy of the statement of *excess* cost which is produced on a machine group basis, via the Labour Performance Sheet and, if the work records are correctly designed, shown also on the work sheets and production records of batch of work.

The variances from standard are automatically recorded as extra time, or extra or less labour rate, and this is available by components for costing purposes and by machine groups and (if necessary) by components for management control. This provides all the data a management needs if it really wants to know the truth.

The data shown up in this way is not always pleasant. The executive who would prefer to remain in ignorance of the shortcomings in his work, and who only wants a comfortable ride, should stick to day-work and nice comfortable overall cost figures.

Standard costs and financial accounts

A. Preparation of Wages Expense

The Labour Cost Control statement shows:—

(i) Standard minutes on measured and unmeasured productive work, i.e., direct work producing a saleable product.

(ii) Clock minutes expended on such indirectly productive work as rectifying scrap, setting machines, and such non-productive activities as " waiting."

To obtain a more complete " labour " cost it is necessary to take into account other payments to labour, such as " merit " rates and cost-of-living bonus.

At this stage the standard minute, which is the correct unit for use when controlling labour utilisation, should be abandoned for the " money " unit to be used for integration in the financial accounts.

If the calculation necessary for producing the Labour Cost Control statement is now converted into money, we then have:—

(a) Direct wages expense on productive work, and the *standard* cost of the work produced.

(b) Wages expense on non-productive work, i.e., excess to standard work.

(c) Merit rates and cost-of-living wages expense which are, of course, a non-productive wages expense.
Where possible these rates would be consolidated in the " direct " wages as part of the payment or rate per sm.

B. Monthly Trading Account (Conventional)

Most firms prepare a monthly Trading Account in which appear:—

1. *Productive Expense*
   (i) Direct Material purchases
   (ii) Direct labour expense
2. *Overheads*
   (i) Manufacturing or factory expense
   (ii) Selling expenses
   (iii) Administrative expenses
3. *Sales*
   (i) Sales invoiced product a
   ,, b
   ,, c
4. *Stock*
   (i) Opening and closing stock
   (ii) Opening and closing work-in-progress account.

These items are the conventional headings under which expenses and sales are recorded, and meet overall accounting requirements.

Unfortunately the overall picture is too general to be any guide to *manufacturing* performance within the period covered by the accounts.

The factors most affected by manufacturing efficiency are the stock and work-in-progress, and it is these figures which are the most difficult to collect in an accurate form over a relatively short period. The magnitude of the figures is such that a 5% error may exceed the net profit. A solution to this problem is outlined below:—

C. Monthly Trading Account (Standard Costs)

From the way in which wages expense is analysed, we have available:—

(a) Direct wages on productive work.
i.e. actual standard cost of the work produced and paid for.

(b) All other wages as *excess* cost to standard, this includes excess of two kinds:—
  (i) excess cost above standard cost due to scrap, waiting, etc., i.e., *avoidable* excesses
  (ii) excess cost which must be borne, i.e., setting supervision, cost-of-living bonus, etc.

1. *Allocation of wages expense (directly productive on standard cost)*

It is practicable to carry these figures from wages accounts to an expense account thus:—

Product Work-in-Progress Account.

DR.			CR.	
Opening W.I.P. at standard cost	£.....		Finished parts to stores at standard labour cost value	
Payroll figures for productive labour i.e. standard cost value				
week ended (i)			week ended (i)	
(ii)			(ii)	
(iii)			(iii)	
(iv)			(iv)	
Closing work-in-progress.				

The finished parts received in stores are treated in the finished stores account thus:—

Finished Stores Stock Account

DR.			CR.	
Opening stock, at standard cost	£.....		Sales at standard labour cost	
Finished parts to Stores at standard labour cost				
week ended (i)			week ended (i)	
(ii)			(ii)	
(iii)			(iii)	
(iv)			(iv)	
Closing stock at standard labour cost.				

In some factories parts are sent from component processing departments to a finished parts store, and later reissued to an assembly shop; after assembly the finished job is either put into stock again or passed straight out as a " sale."

In such cases, the ideal is a work-in-progress account for each stage in manufacture and storage.

(a) *Allocation of wages expense (alleged " productive " wages: actually excess cost)*

This is expense which cannot be recovered directly on the product, i.e., if the company was wound up this labour expense would yield nothing saleable.

The correct treatment of this expense is to carry it into the factory or manufacturing expenses column of the Trading Account, i.e., along with such similar expense as Holiday pay, Salaries, Overtime Premium expense, etc.

Standard costs and operating effectiveness

The conventional Trading Account as described in " B " above is of very little guide to manufacturing or overall operating effectiveness. With the revised method of dealing with work-in-progress and stock as described in " C " above, it becomes possible to adapt the Trading Account figures to produce something of real value as a management measuring tool. Using figures already available in the conventional Trading Account, the following statement can be prepared:

$$\frac{\text{Manufacturing expense} \times 100\%}{\text{Standard cost of work produced value}}$$

This is a measure of the efficiency with which the productive resources are being employed.

When this ratio deteriorates, it is possible to analyse the figures to find the cause, and then take the rectifying action.

Where particular items in the manufacturing expense totals appear to be increasing unreasonably, say, indirect wages, or overtime expense, it is possible to relate these specific expenses to the standard cost value of the work produced, and easily establish whether the gains justify the expense.

When production engineers are struggling to develop the manufacture of a new product, or maintain an output schedule, it is irritating in the extreme to have figures pushed at them showing deterioration in manufacturing effectiveness, or increased expense in some minor non-productive activity. Unfortunately the correct answer to the question, " What is the machine shop for? " is " To make a profit."

Conclusion

The foregoing sections have been written to show some of the ways in which work measurement data can be used to help factory management.

The examples chosen are those relating to batch production machine shops. This is because, in the writer's view, batch production engineering work is one of the most difficult and complex manufacturing techniques, and what applies to it contains the basis for control of simpler plants. It will be seen that control data for labour performance, machine loading standard cost and wages payment all depend upon correct application of work measurement data.

Where correct and full employment of labour is a decisive factor in factory efficiency, and as naturally follows, the cost of the product, then correct work measurement must precede all attempts at control to provide the basis for judging management effort to improve operating efficiency.

REFERENCES:

[1] Measurement of Productivity—Applications & Limitations, issued by Joint Committee Inst. of Cost & Works Accountants and Inst. of Production Engineers.

[2] " Motion & Time Study "—Barnes. Chap. 17.

[3] " Organising for Output " Sect. XIII. Brit. Inst. of Management publication.

[4] " Motion & Time Study "—Barnes. Chap. 18.

[5] " Committee on Rating Time Studies Advanced Management." S.A.M. Journal, July, Sept., 1941.

[6] " Time Study for Cost Control." Carroll.

DEPT. RADIAL DRILLS **No. OF OPERATORS 20 Men** **LABOUR PERFORMANCE SHEET** **APPENDIX I**

Week Ended	Minutes of Work			Clock Hours Worked	Performance Index			Excess Time						Cost of Excess Time	Extra for Rate	Total Excess Cost	Excess Cost Pence Per Min.
	Measured	Un-measured	Total		Measured Work	Extra Work	Paid	Setting Mins.	Extra Mins.	Wtg. Mins.	Scrap Mins.	Reclaim Mins.	Total Mins.				
—	59445	1053	60,498	928¾	65.14	10.82	75.96	4721	4387	705	113	124	10,050	£19–17–7	£1–7–9	£21–5–4	0.084d.

CORRESPONDENCE

The following contribution to the discussion on the 1957 Sir Alfred Herbert Paper (which was reported in the January Journal) has been received from **Dr. J. C. Evans,** of the National Physical Laboratory :

I would like to make a written contribution to the discussion in order to expand a little what I said at the meeting with regard to form. I do so with an easy conscience, because experience persists in showing that engineers have not yet appreciated to the full that they cannot afford these days to assume correctness of form and that, in the last resort, it is the remaining error in form which decides the accuracy of measurement that can ultimately be achieved, be it a thousandth or a millionth of an inch.

Metrology is essentially materialised geometry: in school we learn the geometrical properties of the straight line, the plane, the cylinder and the sphere; and in engineering we use the straightedge, the surface plate, the cylindrical plug and the ball bearing. We are apt to assume that the material objects are endowed with the properties which became so familiar when we studied their geometrical counterparts: this, when we are asked to measure the diameter of a cylindrical plug or hole, we tend to assume that we are dealing with a true cylinder. These assumptions might not have been unduly out of place 40 or 50 years ago, but they are quite untenable in these days of finer and ever finer accuracy. It would be much better, much more efficient if the first question asked about a workpiece was " Is the form right ? " ; *not* " Is the size right ? ".

Least of all can one make assumptions about the form of a standard. The slip gauge represents a length, which is the separation of its two flat and parallel gauging faces ; the first question must be " Are the faces flat and parallel ? ". The cylindrical plug represents a diameter, but is the plug a true cylinder ; here the question of form involves straightness, parallelism and roundness (radial as well as diametral constancy), qualities which are not so easy to judge and assess as those of flatness and parallelism for which the interferometric technique is so powerful an aid.

And then there is the perhaps more subtle point, the influence of form, or rather change of form, on measurement. Even when one has a perfect cylindrical plug standard there still remains the task of determining its size by relation to a slip gauge used as a standard of reference. This at present involves a direct comparison between slip gauge and cylinder in a suitable measuring machine, but a difficulty arises because the compression effects on the two pieces will differ on account of their different geometrical form. At the NPL, the comparison is made in a machine designed by the late Mr. J. E. Sears. This machine has flat, parallel end-faces, a magnification of 30,000, and the measuring force applied to the pieces can be varied in the range 0.5 to 2 lb. By making the comparisons under different measuring forces, an appreciation of the difference in comprehensive effect is obtained experimentally and an allowance made. With the length of the slip gauge known to $\pm$ 1 microinch, the diameter of the cylinder is established to $\pm$ 10 microinches with certainty and probably a little better. For the measurement of cylindrical ring standards, the NPL has in recent years developed a machine which enables the ring to be compared with a " box standard " built up from slip gauges. The measuring force is less than 0.1 oz., so that compression effects are extremely small, and the magnification is 20,000. In this way, again using slip gauges whose sizes are known to $\pm$ 1 microinch, the diameters of rings in the range 0.1 to 3 inches can be determined to $\pm$ 10 microinches ; a larger machine, whilst preserving a similar accuracy, extends the range to 6 inches.

Present research at NPL is directed towards a still further improvement in the accuracy of measurement of standard plugs and rings. After all, machines are not built solely of rectangular parellelepipeds: rotary parts call for cylindrical fits ; holes and shafts must be measured. The slip gauge can be, and is daily, calibrated to $\pm$ 1 microinch, but the standard ring remains as yet at $\pm$ 10 microinches. A new principle for internal measurement is being investigated at the moment and appears very promising. It may enable standard rings to be measured to $\pm$ 5 microinches ; but even if this hope is disappointed and the accuracy achieved is still only $\pm$ 10 microinches, there will be a considerable advantage in having a second machine working on entirely different lines and so providing an independent check. In the case of the standard plug, work is being done in transferring from the slip gauge by means of interferometry. A series of standard plugs, gradually increasing in diameter, will be established in this way and then used as reference standards, so avoiding the present comparison with slip gauges in the routine calibration work. It is so unfortunate that, unlike slip gauges, cylinders cannot be wrung together to form additive (diametral) combinations!

Central London Productivity Week

As the result of setting up a small stand, designed to illustrate the education and promotion prospects in production engineering, at the Central London Productivity Exhibition and Conference held recently at Northampton College of Advanced Technology, the Institution has received a considerable number of enquiries for further information, and for copies of publications. A photograph of the stand appears below.

The Exhibition, which was opened by Sir Walter Puckey, Past President of the Institution, was visited during the week by over 4,000 people, and was designed to illustrate how productivity can be raised, with particular reference to the importance of education in creating skill in workpeople and effectiveness in management.

The Conference which took place concurrently with the Exhibition attracted an attendance of nearly 3,000, and among the subjects discussed were variety reduction, operational research, organisation and methods, and related topics.

Also taking place throughout the week was a continuous programme of the latest films underlining the theme of the Exhibition and Conference.

The Institution's stand, illustrating the education and promotion prospects in production engineering

New Year Honours

The Council of the Institution offers warm congratulations to the following members whose names appeared in the New Year Honours List :-

Companion of Honour

The Viscount Nuffield, G.B.E., Past President.

Knight Bachelor

Mr. S. J. Harley, Member, Coventry Gauge & Tool Co.

C.B.E.

Mr. C. Metcalfe, Member, E.M.I. Electronics Ltd.
Mr. W. A. Summers, Member, Hunting Aviation Ltd.

O.B.E.

Mr. E. W. Hancock, M.B.E., Immediate Past President.
Mr. A. Sykes, Member, David Brown & Sons (Huddersfield) Ltd.

Leicester Section Dinner

The Annual Dinner of the Leicester Section, held last November, was marked by the highest attendance in the history of the Section. Among the principal guests were : the President of the Institution, The Rt. Hon. The Earl of Halsbury; the Lord Mayor of Leicester, Alderman F. J. Jackson; Professor E. A. Stewardson, Head of the Physics Department, Leicester University; Dr. H. L. Haslegrave, of Loughborough Technical College; Mr. S. C. Mason, Director of Education for Leicestershire; and Mr. W. Peck, Chairman of the Peterborough Section.

The photograph at right shows the President being received by the Chairman of the Leicester Section, Mr. L. S. Pitteway (*left*) and Mr. R. M. Evans, Chairman Elect of the Section.

news of members

Mr. J. Blakiston, Member, has been elected President, for the year 1957 - 1958, of The Institute of British Foundrymen.

Mr. E. W. Hancock, M.B.E., Immediate Past President, has been invested as a Serving Brother in the Order of St. John of Jerusalem.

Mr. E. H. Holder, Member, has been transferred from the Royal Ordnance Factory, Radway Green, Cheshire, to the Ministry of Supply, London, as Training and Education Officer.

Mr. A. S. Johnstone, Member, who was Chairman of the Nottingham Section of the Institution prior to the formation of the Lincoln Section, has just completed 29 years' service with Robey and Co. Ltd., where he is Works Manager. Mr. Johnstone is also a Past President of the Lincoln Engineering Society and of the Institute of Welding.

Colonel J. M. Lyden, O.B.E., Member, is now Chief Electrical and Mechanical Engineer, Headquarters, East Africa and Land Forces, Kahawa, Nairobi.

Mr. T. H. Phillipson, Member, Technical Director of Rose Bros., Gainsborough, has been appointed to the board. Mr. Phillipson has been with the firm since 1914. He is also a director of a subsidiary undertaking, the Northern Manufacturing Company.

Mr. G. R. Whitehead, Member, has taken up an appointment as General Manager of the Wolsingham Steel Co. Ltd., Bishop Auckland, Co. Durham. Mr. Whitehead was, until taking up his new appointment, Chairman of the Doncaster Section.

Mr. A. H. Bevan, Associate Member, has relinquished his position as Senior Assistant Manager of the Central Work Study Department, Guest Keen & Nettlefolds (Midlands) Limited, and has taken up the appointment of Production Engineer to George Goodman Limited, Hall Green, Birmingham.

Mr. G. A. Crook, Associate Member, has recently taken up a position as Head of Engineering at the Newport and Monmouthshire College of Technology.

Mr. A. G. McKay, Associate Member, has taken up an appointment as Factory Manager to the Stoke Factories of the Dunlop Rubber Co. Ltd.

Mr. P. Oppenheimer, Associate Member, has recently taken up an appointment as Manager of the Fractional Horsepower Motor Department of Newman Industries Limited, Yate. He is a Past Chairman of the London Graduate Section, and he was, until taking up his new appointment, a member of the Birmingham Section Committee. He also serves on the Institution's Research Committee.

Mr. L. H. Osborne, Associate Member, has been appointed to the South of Scotland Electricity Board as Principal Assistant Engineer (Mechanical and Electrical).

Mr. J. W. Powell, Associate Member, has been appointed a Director of Porter Prototype Engineering Company (Birmingham) Limited.

Mr. R. W. Ransome, Associate Member, has recently left England to take up an appointment with Industrial Engineering Limited, Westfootscray, Victoria, Australia.

Mr. C. Sargent, Associate Member, has been appointed Works Manager (Foundry & Engineering Division) and elected local director of the Fitzwilliam Works of Darwins Limited, Sheffield.

Mr. R. D. Tomkinson, Associate Member, has relinquished his appointment as Works Manager to the Kenwood Manufacturing Co. Ltd., and is now General Manager, Blackwater Area, Microcell Ltd., Camberley, Surrey.

Mr. W. E. Turner, Associate Member, has recently taken up the position of General Manager of Nobrac-Carbon Limited, Lancing, Sussex.

Mr. G. W. Voaden, Associate Member, has recently taken up an appointment as Chief Draughtsman with the National Coal Board at their Area Mechanical Reconstruction Department, at Fenton, Stoke-on-Trent. Mr. Voaden was previously a Mechanical Engineer with Messrs. Thomas Bolton & Sons Limited, of Froghall, Stoke-on-Trent.

Mr. G. C. Wadsworth, Associate Member, has been appointed Managing Director of Shannon Jewellery Limited, Carrick-on-Shannon, and also a Director of Shannon Industries Limited, Drumsna. He was previously General Manager of General Plastics Limited.

Mr. J. M. Barber, Graduate, is now a Management and Production Consultant at Noel Clark & Partners Limited, London.

Mr. D. Burrows, Graduate, has recently taken up an appointment as Assistant Grade 'B' Lecturer in Mechanical and Production Engineering subjects at Mid-Herts. College of Further Education, Welwyn Garden City, Herts.

Mr. J. Keightley, Graduate, has recently taken up an appointment as Chief Draughtsman with Messrs. W. H. Baxter Limited, Leeds. Mr. Keightley is Hon. Secretary of the Leeds Graduate Section.

Mr. J. D. Rogan, Graduate, is now employed as an Engineer III by the Ministry of Supply in the capacity of Shop Manager, "A" Division Workshops, Royal Aircraft Establishment, Farnborough.

Mr. C. A. G. Turner, Graduate, has recently joined the Production Engineering Research Association, as a Research Engineer.

MATERIALS HANDLING GROUP

Section Representatives

With reference to the list published on page 52 of the January Journal, the following change of address should be noted :-

PRESTON — H. S. Carleton, A.M.I.Prod.E., 95 Liverpool Road South, Burscough, Lancs.

OBITUARY

As this issue of the Journal was going to Press, the Institution received the sad news of the deaths of two well-known members, Mr. Alastair McLeod, of Industrial Newspapers Ltd., and Mr. Frank Woollard, M.B.E.

Full appreciations will appear next month.

DIARY FOR 1958

6th February ...	**The 1957 Viscount Nuffield Paper,** to be presented at the University of Bristol. Speaker : **Lord Hives.** Subject : **"Technical Education for Production Engineers".**
24th March	**The 1957 George Bray Memorial Lecture,** to be presented at the University of Leeds. Speaker : **Dr. V. E. Yarsley.** Subject : **"The Fabrication of Plastics".**
9th and 10th April ...	Conference on **"Compressed Air in Industry",** Camborne, Cornwall.
12th - 21st May ...	**Production Conference and Exhibition,** Olympia — **"Production Fights Inflation".**
21st May	**Fourth Conference of Engineers** and those responsible for Standards matters in Industry, London.
27th - 31st August ...	**Annual Summer School,** Ashorne Hill, Warwickshire.
13th, 14th, 15th October	**Materials Handling Convention,** Brighton.
29th October	**Annual Dinner of the Institution,** Dorchester Hotel, London.

PERIODICALS CURRENTLY RECEIVED

Aero Research Technical Notes. Duxford, Cambridge, Aero Research Ltd. Monthly. *From No. 1, January, 1943.*

Aircraft Engineering. London, Bunhill Publications Ltd. Monthly. *5 years.*

Aircraft Production. London, Iliffe and Son Ltd. Monthly. *5 years.*

Aluminium Courier. London, Aluminium Development Association. Irregular. *6 issues.*

Aluminium Development Association, *London. See* Aluminium Courier.

Aluminium News. Montreal, Aluminium Union Ltd. Monthly. *6 months.*

Aluminium Union Ltd., Montreal. *See* Aluminum News.

American Institute of Industrial Engineers. *See* Journal of Industrial Engineering.

American Machinist. New York, McGraw-Hill Publishing Company Inc. Bi-weekly. *5 years.*

American Management Association, *New York. See* Management Review.

American Materials Handling Society Inc., *Toledo, Ohio. See* Modern Materials Handling.

American Society for Metals, *Cleveland, Ohio. See* Metal Progress.

American Society of Mechanical Engineers, *New York. See* Mechanical Engineering.

American Society of Tool Engineers, *Detroit, Mich. See* The Tool Engineer.

Andre Rubber Company Ltd., *Surbiton. See* Torque.

Applied Hydraulics. Cleveland, Ohio. Hydraulics Publishing Co. Monthly. *2 years.*

Arbeitgemeinschaft Deutscher Betrebsingenieure. *See* Werkstattstechnik und Maschinebau.

Arbeitsgemeinschaft für Furtigungstechnisches Messwesen im VDI. *See* Werkstattstechnik und Maschinenbau.

Aslib Book-List. London, Aslib. Monthly. *3 months.*

Aslib Proceedings, incorporating Aslib Information. London, Aslib. Monthly. *1 year.*

Aslib, *London.* Journal of Documentation, q.v.

Associated British Machine Tool Makers Ltd., *London. See* British Machine Tool Engineering.

Association des Ingenieurs sortis de l'Universite Libre de Bruxelles, Brussels. *See* Revue Generale des Sciences Appliquees.

Association Française des Conseils en Organisation Scientificque, Paris. Bulletin. Monthly. *1 year.*

Associazione Meccanica Italiana, Milan. *See Rivista di* Meccanica.

Austin Technical News: abstracts from the world's scientific and technical press. Birmingham, Austin Motor Co. Ltd. Monthly *6 months.*

Australian Institute of Management, Sydney Division. *See* Management News.

Australian Institute of Management, Adelaide Division. *See* Management Digest.

Automation. Cleveland, Ohio, Penton Publishing Co. Inc. Monthly. *2 years.*

Automation Progress. London, Leonard Hill Technical Group. *From Volume 1, 1956.*

Automobile Engineer. London, Iliffe and Sons Ltd. Monthly. *5 years.*

B.P.C. Bulletin. London, British Productivity Council. Monthly. *6 months.*

B.S.C.R.A. Abstracts. Sheffield, British Steel Castings Research Association. Bi-monthly. *1 year.*

B.S.I. Information Sheet. London, British Standards Institution. Monthly. *1 year.*

Bacie Journal. London, British Association for Commercial and Industrial Education. Bi-monthly. *From Volume 7, No. 2, March/April, 1953.*

Ball Bearing Journal: a quarterly publication devoted to anti-friction engineering. Luton, Skefko Ball Bearing Co. Ltd. *6 months.*

Beama Journal: the official Journal of the British Electrical and Allied Manufacturers Association (Inc.). Monthly. *5 years.*

Bearing Engineer. New York, Torrington Co. *6 months.*

Bibliography of Industrial Diamond Applications. London, Industrial Diamond Information Bureau. Monthly *2 years.*

Bibliotech: library bulletin of the College of Technology, Birmingham. Bi-monthly. *1 issue.*

Birmingham College of Technology. Library. *See* Bibliotech.

Board of Trade Journal. London, H.M.S.O. Weekly *2 years.*

The Bonderizer, Brentford, The Pyrene Co. Ltd. *6 months.*

British Aluminium Co., London. *See* Light Metals Bulletin.

British Association for Commercial and Industrial Education, London. *See* Bacie Journal.

British Cast Iron Research Association, Birmingham. Bulletin and Foundry Abstracts. *1 year.*

British Electrical and Allied Manufacturers Association (Inc.), London. *See* Beama Journal.

British Institute of Management, London. Journal. Quarterly. *From Volume 1, No. 1, 1957* (and as British Management Review, *from Volume 11, 1952/3*).

British Institute of Management, London. Library Bulletin. Monthly. *1 year.*

British Institute of Management, London, Management Abstracts. q.v.

British Institution of Radio Engineers, London. Journal. Monthly. *1 year.*

British Machine Tool Engineering. London, Associated British Machine Tool Makers Ltd. Quarterly. *6 months.*

British Management Review. *See* British Institute of Management. Journal.

British Packer, incorporating British Glass Packer. London, Cam Publications Ltd. Monthly. *2 years.*

British Plastics. London, Iliffe and Sons Ltd. Monthly. *5 years.*

British Productivity Council, London. *See* B.P.C. Bulletin.

British Radio and Television. London. Monthly. *1 issue.*

British Rubber Development Board, London. *See* Rubber Developments.

British Standards Institution, London. *See* B.S.I. Information Sheet.

British Standards Institution, London. British Standard Specifications. (The Library has a file of those B.S.I. specifications, which are of interest to production engineers.)

British Steel Castings Research Association, Sheffield. *See* B.S.C.R.A. Abstracts.

British Tabulating Machine Co. London. *See* The Tabulator.

British Timken Ltd., Northampton. *See* Timken Times and FBC Bulletin.

British Welding Journal. London, Institute of Welding and British Welding Research Association. Monthly. *1 year.*

British Welding Research Association, London. *See* British Welding Journal.

Brush Group, London. Technical Journal. Quarterly. *6 months.*

Bureau des Temps Elementaires, Paris. *See* Etude du Travail.

Business. London, Business Publications Ltd. *1 year.*

C.N.O.F.: Revue mensuelle de l'organisation. Paris, Comité National de l'Organisation Française. Monthly. *1 year.*

California Texas Oil Company Ltd., New York. *See* Lubrication; and Oil, Lifestream of Progress.

Central Statistical Office. *See* Monthly Digest of Statistics.

Centre de Documentation de la Mecanique, Paris. *See* Documentation Mecanique.

Centralny Instytut Dokumentatacji Naukowo-Technicznej, Warsaw. *See* Polish Technical Abstracts.

Centre de Documentation Siderurgique, Paris. Bulletin Analytique en collaboration avec le Centre National de la Recherche Scientifique. Monthly. *1 year.*

Centre de Documentation Siderurgique, Paris. Circulaire d'Informations Techniques. Monthly. *1 year.*

Chartered Civil Engineer. London, Institution of Civil Engineers. Monthly. *1 year.*

Chartered Mechanical Engineer. London, Institution of Mechanical Engineers. Monthly. *1 year.*

Cold Rolled Sections Association, Birmingham. *See* Sheet Metal Industries.

Comitato Nazionalè per la Prodittivitá, Rome. *See* Cronache della Produttivitá; and Produttivitá.

Comité National de l'Organisation Française, Paris. *See* C.N.O.F.

Compressed Air Engineering. London, John Trundell (Publishers) Ltd. Monthly. *2 years.*

Coming Events. Paris, European Productivity Agency. Monthly. *1 year.*

Control Engineering. New York, McGraw-Hill Publishing Co. Inc. Monthly. *Volume 2, No. 8, 1955.*

Copper Development Association, Radlett, Hertfordshire. Technical Survey. Half-yearly. *1 year.*

Cost Accountant. London, Institute of Cost and Works Accountants. Monthly. *1 year.*

Cronache della Produttivitá. Rome, Comitato Nazionale per la Produttivitá. Fortnightly. *1 year.*

Crossley Chronicles. Manchester, Crossley Brothers Ltd. Irregular. *6 months.*

The Director. London, Institute of Directors. Monthly. *1 year.*

Documentation Mecanique. Paris, Centre de Documentation de la Mecanique. Monthly. *1 year.*

Doelmatig Bedrijfsbeheer. Alphen aan den Rijn, N. Samson, N.V. Monthly *1 year.*

Drawing Office Announcer. *Now* Engineering Designer. q.v.

Economist. London, Economist Newspaper Ltd. Weekly. *6 months.*

Edgar Allen News. Sheffield, Edgar Allen and Co. Ltd. Monthly. *6 months.*

Ecole d'Organisation Scientifique du Travail, *Paris. See* Trait d'Union.

Electrical Journal. London, Benn Brothers Ltd. Weekly. *2 years.*

Electrical Manufacturer. London, J. V. Brittain. Bi-monthly. *2 years.*

Electrical Review. London, Electrical Review Publications Ltd. Weekly. *5 years.*

Electronic Application Bulletin, for the electronic equipment and set-making industries. Eindhoven, N.V. Philips' Gloeilampenfabriken. *2 years.*

Elliott Journal. London, Elliott Brothers (London) Ltd. Half-yearly. *6 months.*

Engineer. London, Morgan Brothers (Publishers) Ltd. Weekly. *5 years.*

Engineer and Foundryman: official Journal of the Steel and Engineering Industries Federation of South Africa. Johannesburg, Tearle. Monthly *1 year.*

Engineer Apprentice and Engineer Student. London, Trade and Technical Press Ltd. Monthly *1 year.*

Engineering. London, Engineering Ltd. Weekly. *5 years.*

Engineering Designer, incorporating the Drawing Office Announcer (Organ of the Institution of Engineering Designers). London, F. P. Kennett. Monthly. *1 year.*

Engineering Index. New York, Engineering Index Inc. Annual. *From 1950.*

Engineering Industries Bulletin. London, Engineering Industries Association. Monthly. *1 year.*

Engineering Inspection. London, Institution of Engineering Inspection. Quarterly. *1 year.*

Engineering Institute of Canada, *Montreal. See* Engineering Journal.

Engineering Journal. Montreal, Engineering Institute of Canada. Monthly. *1 year.*

Engineers' Digest. London, Engineers' Digest Ltd. Monthly. *5 years.*

English Electric Journal. Stafford, English Electric Company Ltd. Quarterly. *6 months.*

Esso Oilways. London, Esso Petroleum Company Ltd. Irregular. *6 issues.*

Etude du Travail: revue mensuelle du Bureau des Temps Elementaires. Paris, Editions d'Organisations. Monthly. *1 year.*

Factory Manager, incorporating the Works Manager. London, Production Publications (London) Ltd. Monthly. *1 year.*

Factory Management and Maintenance. New York, McGraw-Hill Publishing Co. Inc. Monthly. *5 years.*

Fasteners. Cleveland, Ohio, Industrial Fasteners Institute. Irregular. *12 issues.*

Fenner, J. H., and Co. Ltd., Hull. *See* V-Belt Journal.

Flow. Cleveland, Ohio, Flow Publishing Co. Monthly. *5 years.*

Foundry Trade Journal, with which is incorporated the Iron and Steel Trades Journal. London, Industrial Newspapers Ltd. Weekly. *5 years.*

Furniture Development Council, *London.* Technical Bulletin. Bi-monthly. *1 year.*

G.E.C. Journal. London, General Electric Company Ltd. Quarterly. *6 months.*

Government Publications: Consolidated List. London, H.M.S.O. Annual. *From 1951.*

Government Publications: Monthly List. London, H.M.S.O. Monthly. *1 year.*

Grits and Grinds. Worcester, Mass., Norton Company. Monthly. *6 months.*

Haynes Alloys Digest. International Edition. New York, Haynes Stellite Department, Union Carbide International Company. Irregular. *6 issues.*

Heating and Air Treatment Engineer. London, Princes Press Ltd. Monthly. *1 year.*

Herbert, Alfred, Ltd., *Coventry. See* Machine Tool Review.

Hiduminium Abstract Bulletin. Slough, Buckinghamshire, High Duty Alloys Ltd. Monthly. *1 year.*

High Duty Alloys Ltd., *Slough Buckinghamshire. See* Hiduminium Abstract Bulletin.

Hommes et Techniques. Paris, Hommes et Techniques. Monthly. *1 year.*

Hungarian Technical Abstracts. Budapest, National Technical Library. Quarterly. *1 year.*

I.A.A.E. Journal. *See* Institution of Automotive and Aeronautical Engineers, Melbourne. Journal.

Incorporated Sales Managers' Association, *London. See* Marketing.

Index Aeronauticus. London, TPA3 Technical Information Bureau for Chief Scientifist, Ministry of Supply. Monthly. *1 year.*

India Society of Engineers, *Calcutta. See* Science and Engineering.

Indian and Eastern Engineer, incorporating Indian and Eastern Motors. Calcutta, Samar Gupta. *1 year.*

Industrial Arts Index. New York, H. W. Wilson Company. Monthly. *From 1950.*

Industrial Diamond Review, incorporating Bibliography of Industrial Diamond Applications. London, N.A.G. Press Ltd. Monthly. *2 years.*

Industrial Equipment News. London, Industrial Equipment News. Monthly. *6 months.*

Industrial Fasteners Institute, *Cleveland. Ohio. See* Fasteners.

Industrial Welfare and Personnel Management. London, Industrial Welfare Society Inc. Bi-monthly. *2 years.*

Industrial Welfare Society, *London. See* Industrial Welfare and Personnel Management.

Industrial Management Research Association, *London.* Confidential Bulletin. Monthly. *6 months.*

Informes de la Construcción. Madrid, Instituto Tecnico de la Construcción y del Cemento. Monthly. *1 year.*

Institute of British Foundrymen, *Manchester.* Proceedings. Annual. *1 year.*

Institute of Cost and Works Accountants, *London. See* Cost Accountant.

Institute of Directors, *London. See* The Director.

Institute of Industrial Administration, *London. See* British Management Review.

Institute of Industrial Supervisors, *Birmingham. See* The Supervisor.

Institute of Industrial Technicians, *Liverpool. See* Time and Motion Study.

Institute of Marine Engineers, *London.* Transactions. Monthly. *1 year*

Institute of Metal Finishing, incorporating the Electro-depositors' Technical Society, *London.* Transactions. Irregular. *1 year.*

Institute of Personnel Management, *London.* See Personnel Management.

Institute of Road Transport Engineers, *London.* Journal and Proceedings. Three issues per annum. *1 year.*

Institute of the Motor Industry, *London.* Journal. Quarterly. *1 year.*

Institute of Vitreous Enamellers, *Ripley. See* Sheet Metal Industries.

Institute of Welding, London. British Welding Journal. q.v.

Institution of Automobile Engineers, *London.* Proceedings. Annual. Volume 20, 1925/6; Volume 24, 1929/30; Volume 27, 1932/3 - Volume 40, 1945/6. Later issues entered under Institution of Mechanical Engineers — Automobile Division.

Institution of Automotive and Aeronautical Engineers, *Melbourne.* Journal. Monthly. *1 year.*

Institution of Civil Engineers, *London.* Chartered Civil Engineer. q.v.

Institution of Civil Engineers, *London.* Proceedings. Monthly. Issued in three parts; Part I, bi-monthly; Parts II and III each three times per annum. *1 year.*

Institution of Electrical Engineers, *London.* Proceedings, Part I, General. Bi-monthly.

Institution of Engineering Designers, *London. See* Engineering Designer.

Institution of Engineering Inspection, *London. See* Engineering Inspection.

Institution of Engineers and Shipbuilders in Scotland, *Glasgow.* Transactions. Seven times per annum. *1 year.*

Institution of Engineers, Australia, Sydney. Journal. Monthly. *1 year.*

Institution of Heating and Ventilating Engineers, *London.* Journal. Monthly. *1 year.*

Institution of Mechanical Engineers, *London.* Chartered Mechanical Engineers. q.v.

Institution of Mechanical Engineers, *London.* Proceedings. Annual. *From Volume 147, 1942.*

Institution of Mechanical Engineers, *London.* Automobile Division. Proceedings. Annual. *From 1947/8.*

Institution of Production Engineers, *London.* Journal. Monthly. *From Volume 1, 1921/2.*

Institution of Works Managers, *London. See* Works Management.

Instituto Tecnico de la Construcción y del Cemento, *Madrid. See* Informes de la Construcción.

Instrument Engineer. Luton, George Kent Ltd. Half-yearly. *1 year.*

International Institution for Production Engineering Research, *Paris. See* Microtecnic.

Irish Engineering Building and Construction. Dublin Parkside Press Ltd. Monthly. *1 year.*

Iron Age. Philadelphia, Chilton Publishing Co. Inc. Monthly. *From Volume 167, January - June, 1951.*

Iron and Coal Trades Review. London, Industrial Newspapers Ltd. Weekly. (Organ of the National Association of Colliery Managers and the Association of Colliery Managers in India.) *From Volume 166, January - June, 1953.*

Iron and Steel Institute, *London.* Journal. Monthly. *From Volume 163, September - December, 1949.*

Journal of Applied Pneumatics. Richmond, Martonair Ltd. Quarterly. *1 year.*

Journal of Documentation. London, Aslib. Quarterly. *1 year.*

Journal of Industrial Engineering. Atlanta, Georgia, American Institute of Industrial Engineers Inc. Bi-monthly. *From Volume 5, 1954.*

Junior Institution of Engineers, *London.* Journal. Monthly. *1 year.*

Leeds Association of Engineers, *Leeds.* Annual Report and Journal. Annual. *1 issue.*

Light Metals Bulletin. British Aluminium Company Ltd., Intelligence Dept. Fortnightly. *1 year.*

Lubrication. New York, California Texas Oil Company Ltd. Monthly. *6 months.*

Machine and Tool Blue Book. Wheaton, Ill. Hitchock Publishing Company. Monthly. *From Volume 49, 1953.*

Machine Design. Cleveland, Penton Publishing Company. Monthly. *From Volume 25, 1953.*

Machine Shop Magazine. London, Iliffe and Son Ltd. Monthly. *2 years.*

Machine-tool Review. Coventry, Alfred Herbert Ltd. Bi-monthly. *2 years.*

Machinery (London). London, Machinery Publishing Company Ltd. Weekly. *From Volume 61, July-December, 1942.*

Machinery (New York). New York, Industrial Press. *From Volume 60, 1953/54.*

Machinery Lloyd. European and Overseas Editions. London, Continental and Overseas Organisation Ltd. Weekly. *6 months.*

Machinery Market. London, Machinery Market. Weekly. *6 months.*

Machinist, The. *See* Metalworking Production

Magnesium Elektron Ltd., *Manchester. See* Magnesium Review and Abstracts.

Magnesium Review and Abstracts. Manchester, Magnesium Elektron Ltd. Irregular. *1 year.*

Management Abstracts. London, British Institute of Management. Monthly. *From Volume 1, 1948.*

Management Digest. Adelaide, Australian Institute of Management, Adelaide Division. Bi-monthly. *2 years.*

Management News. Sydney, Australian Institute of Management, Sydney Division. Monthly. *2 years.*

Management Review. New York, American Management Association. Monthly. *1 year.*

Manager, The. London, Management Publications Ltd. Monthly. *2 years.*

Marketing. London, Incorporated Sales Managers' Association. Monthly. *1 year.*

Martonair Ltd., *Richmond. See* Journal of Applied Pneumatics.

Mass Production. London, Sawell Publications Ltd. Monthly. *2 years.*

Material Handling Engineering. *See* Modern Materials Handling.

Materials and Methods. New York, Reinhold Publishing Corporation. Monthly. *From Volume 37, January - June, 1953.*

Mechanical Engineering. Easton, Pa., American Society of Mechanical Engineers. Monthly. *From Volume 37, 1950.*

Mechanical Handling. London, Iliffe and Son Ltd. Monthly. *From Volume 37, 1950.*

Mechanical World and Engineering Record, Manchester and London, Emmott and Co. Ltd. *2 years.*

Metal Progress. Cleveland, Ohio, American Society for Metals. Monthly. *2 years.*

Metal Treatement and Drop Forging: official organ of the National Association of Drop Forgers and Stampers. London, Industrial Newspapers Ltd. Monthly. *5 years.*

Metalworking. Orange, Conn., Sutton Publishing Company. Monthly. *1 year.*

Metalworking Production, incorporating the Machinist. London, McGraw-Hill Publishing Company Ltd. Weekly. *5 years.*

Metropolitan-Vickers Electrical Company Ltd., Manchester. Research Dept. Technical News Bulletin. Weekly. *1 year.*

Microtecnic: international review for production engineering research, scientific and industrial metrology, inspection and optics. Official bulletin of the International Institution for Production Engineering Research. Lausanne, Scriptar Ltd. Bi-monthly. *2 years.*

Mill and Factory. New York, Conover-Mast Publications Inc. Monthly. *From Volume 58, No. 1, 1956.*

Ministry of Labour Gazette. London, H.M.S.O. Weekly. *2 years.*

Ministry of Supply — Technical Information Bureau. *See* Index Aeronauticus.

Modern Machine Shop. Cincinnati, Gardner Publications Inc. Monthly. *2 years.*

Modern Materials Handling. (Including Material Handling Engineering, official publication of the American Material Handling Society Inc.) Boston, Mass., Materials Handling Laboratories Inc. Monthly. *5 years.*

Mond Nickel Company Ltd., *London. See* Nickel Bulletin.

Monthly Digest of Statistics; prepared by the Central Statistical Office. London, H.M.S.O. Monthly. *1 year.*

M.O.R. Group of Companies. *See* Oil.

Murex Review. Rainham, Essex, Murex Ltd. Irregular. *6 issues.*

National Research Development Corporation, London. *See* NRDC Bulletin.

National Association of Colliery Managers. *See* Iron and Coal Trades Review.

National Association of Drop Forgers and Stampers, *Birmingham. See* Metal Treatment and Drop Forging.

National Institute of Industrial Psychology, *London. See* Occupational Psychology.

NRDC Bulletin: a quarterly review of inventions available for introduction to industry. London, National Research Development Corporation. Quarterly. *1 year.*

National Technical Library, Budapest. *See* Hungarian Technical Abstracts.

Nederlands Instituut voor Documentatie en Registratuur, *The Hague. See* Tijdschrift voor Efficientie en Documentatie.

New Zealand Engineering: Journal of the New Zealand Institution of Engineers. Wellington, Technical Publications Ltd. Monthly. *1 year.*

New Zealand Institution of Engineers, *Wellington. See* New Zealand Engineering.

Nickel Bulletin. London, Mond Nickel Company Ltd. Monthly. *1 year.*

North East Coast Institution of Engineers and Shipbuilders, *Newcastle upon Tyne.* Transactions. Eight issues per annum. *1 year.*

Norton Company, *Worcester Mass. See* Grits and Grinds.

O.R.: Operational Research Quarterly. London, Operational Research Society. *From Volume 1, 1950.*

Occupational Psychology. London, National Institute of Industrial Psychology. Quarterly. *2 years.*

Office Management: the Journal of the Office Management Association. Monthly. *1 year.*

Oil. London, M.O.R. Group of Companies. Quarterly. *1 year.*

Oil Lifestream of Progress. New York, California Texas Oil Company Ltd. Quarterly. *1 year.*

Operational Research Society, *London. See* O.R.: Operational Research. Quarterly.

Operations Society of America, *Baltimore, Md.* Journal. Quarterly. *Volume 2, 1954.*

Patronato Juna de la Cierva de Investigación Tecnica, *Madrid. See* Revista de Ciencia Aplicada.

Pera Bulletin. Melton Mowbray, Production Engineering Research Association of Great Britain. Monthly. *From Volume 1, 1947/8.*

Personnel Management. London, Institute of Personnel Management. Quarterly. *1 year.*

Personnel Management Welfare and Industrial Equipment. London, Shaw Publishing Company Ltd. Monthly. *1 year.*

Philips, N.V. Gloelampenfabriken, *Eindhoven. See* Electronic Applications Bulletin; Philips Serving Science and Industry; Philips Technical Review.

Philips Serving Science and Industry. Eindhoven, N.V. Philips Gloelampfabriken. Bi-monthly. *1 year.*

Philips Technical Review. Eindhoven, N.V. Philips Gloelampfabriken. Monthly. *1 year.*

Polish Technical Abstracts. Warsaw, Centralny Instytut Dokumentacji Naukowo-Technicznej. Quarterly. *1 year.*

Power Transmission. London, Trade and Technical Press. Monthly. *2 years.*

Precision Metal Molding. Cleveland, Technical Publishing Company Ltd. Monthly. *2 years.*

Process Control and Automation. London, Colliery Guardian Company Ltd. Monthly. *From January, 1955.*

Product Engineering. New York, McGraw-Hill Publishing Company Inc. Weekly. *5 years.*

Product Finishing. London, Sawell Publications Ltd. Monthly. *5 years.*

Production Enginering Research Association of Great Britain, *Melton Mowbray. See* Pera Bulletin.

Produttivitá. Rome Comitato Nazionale per la Produttivitá. Monthly. *1 year.*

Pyrene Company, *Brentford, Middlesex. See* The Bonderizer.

Refa Nachrichten: zeitschrift fur Arbeitsstudien. Darmstadt, Hrsg. vom Verband fur Arbeitsstudien. Quarterly. *5 years.*

Revista de Ciencia Aplicada. Madrid, Patronato Juan de la Cierva de Investigación Tecnica. Bi-monthly. *1 year.*

Revue Générale des Sciences Appliquées: bulletin technique des Ingenieurs sortis de l' Université Libre de Bruxelles. Bi-monthly. *1 year.*

Reynolds Metals Technical Advisor. Louisville Kentucky, Reynolds Metals Company. Irregular. *6 issues.*

Rivista di Meccanica. Milan, Associzione Meccanica Italiana. Fortnightly. *1 year.*

Rotol and British Messier Digest. Gloucester, Rotol Ltd., and British Messier Ltd. Monthly. *6 months.*

Royal Aeronautical Society, *London.* Journal. Monthly. *1 year.*

Rubber Developments. London, British Rubber Development Board. Quarterly. *1 year.*

Science and Engineering. Calcutta, India Society of Engineers. Bi-monthly. *1 year.*

Scientific Lubrication. Brosely, Shropshire, Scientific Publications. Monthly. *2 years.*

Screw Machine Engineering. Rochester, New York, Screw Machine Publishing Company Inc. Monthly. *2 year.*

Sheet and Strip Metal Users' Association, *London. See* Sheet Metal Industries.

Sheet Metal Industries, incorporating Metal Finishing: the official organ of the Institute of Vitreous Enamellers; Sheet and Strip Metal Users' Association; Sheet Metal Industries Association; Cold Rolled Sections Association; Cold Rolled Steel Strip Association. London, Industrial Newspapers Ltd. *From Volume 28, 1950.*

Sheet Metal Industries Association Ltd., *London. See* Sheet Metal Industries.

Shell Magazine. London, Shell Group of Companies. Monthly. *6 months.*

Silentbloc Ltd., London. *See* Torque.

Skefko Ball Bearing Company Ltd., *Luton. See* Ball Bearing Journal.

Society of Industrial Engineers, *London. See* Work Study and Industrial Engineering.

South Wales Institute of Engineers, *Cardiff.* Proceedings. Three times per annum. *1 year.*

Swiss Association of Machinery Manufacturers, *Zurich. See* Swiss Technics.

Swiss Technics. Lausanne, Swiss Office for the Development of Trade, in co-operation with the Swiss Association of Machinery Manufacturers, Lausanne. Three times per annum. *1 year.*

Tabulator, The. London, British Tabulating Machine Company Ltd. Irregular. *6 issues.*

Technology. London, the Times. Monthly. *From Volume 1, No. 1, 1957.*

Textile Institute, Manchester. Journal. Monthly. *From Volume 45, 1954.*

Tijdschrift voor Efficientie en Documentatie: organ van het Nederlands Instituut voor Efficiency, het Nederlands Instituut voor Documentatie en Registratuur, en van de Nederlandse Verneging van Bedrijfsarchivarissen. The Hague, Nederlands Institutte voor Efficientie. Monthly. *1 year.*

Time and Motion Study: Journal of the Institute of Industrial Technicians. London, Sawell Publications Ltd. Monthly. *From Volume 1, October - December, 1952.*

Times Review of Industry. London, the Times. Monthly. *2 years.*

Timken Times and FDC Bulletin. Northampton, British Timken Ltd. Monthly. *1 year.*

Tool Engineer. Milwaukee, Wis. American Society of Tool Engineers. *From Volume 23, July - December, 1949.*

Toolmaker and Precision Engineer. London, Sawell Publications Ltd. Monthly. *2 years.*

Torque. London, Silentbloc Ltd., and the Andre Rubber Company. Quarterly. *1 year.*

Torrington Company, *Torrington, Conn. See* Bearing Engineer.

Trait d'Union: Bulletin mensuel de l'Amicale des Anciens Eleves se l'Ecole d'Organisation Scientifique du Travail. Paris, Sonneville. Monthly. *1 year.*

Union Carbide International Company, *New York. See* Haynes Alloys Digest.

V-Belt Journal. Hull, J. H. Fenner and Co. Ltd. Quarterly. *1 year.*

Verband fur Arbeitsstudien, E.V. *See* Refa Nachrichten.

Warsaw — Centralny Instytut Dokumentatacji Naukowo-Technicznej. *See* Polish Technical Abstracts.

Welding and Metal Fabrication. London, Iliffe and Son Ltd. Monthly. *2 years.*

Werkstatt und Betrieb. Munich, Carl Hanser Verlag. Monthly. *2 years.*

Wekstattstechnik und Maschinenbau: organ der Arbeitsgemeinschaft deutscher Betriebsingenieure und Arbeitsgemeinschaft für fertigungstechnisches Messwesen im VDI. Berlin, Carl Springer Verlag. Monthly. *1 year.*

Whittakers Cumulative Book List. London, J. Whittaker and Sons Ltd. Quarterly. *From 1951.*

Wiggin Nickel Alloys. Birmingham, Henry Wiggin and Co. Ltd. Irregular. *6 issues.*

Woman Engineer. London, Women's Enginering Society. Quarterly. *1 year.*

Work Study and Industrial Engineering. London, Management Publications Ltd., for the Work Study Society and the Society of Industrial Engineers. Monthly. *From Volume 1, No. 1, January, 1957.* (Replaces the Work Study Journal, official publication of the Work Study Society. *From Volume 2, No. 8, March, 1952.*

Work Study Society, Manchester. *See* Work Study and Industrial Engineering.

Works Management: official organ of the Institution of Works Managers. London, Drury Press Ltd. Monthly. *1 year.*

Z.D.A. Abstracts. Oxford, Zinc Development Association. Monthly. *1 year.*

Zinc Bulletin. Oxford, Zinc Development Association. Irregular. *12 issues.*

Zinc Development Association, *Oxford. See* Z.D.A. Abstracts.

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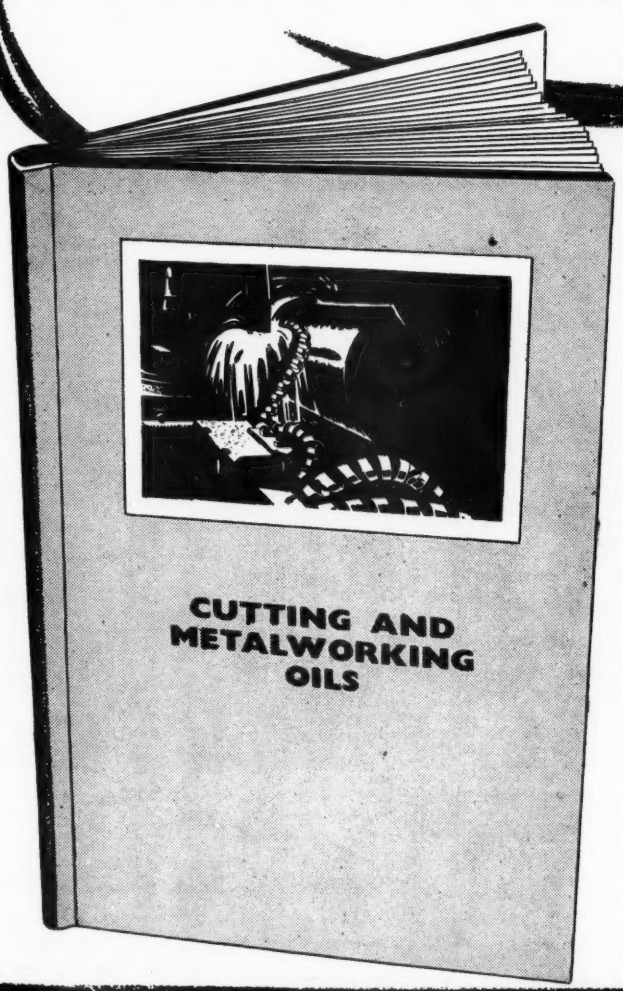

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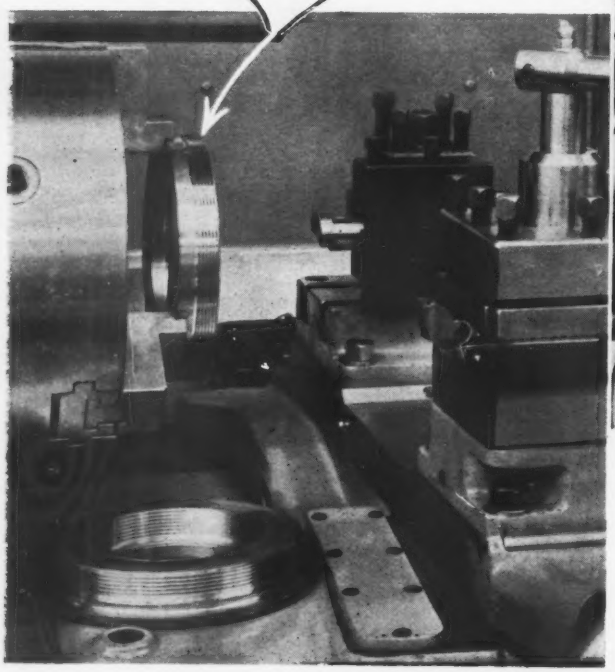

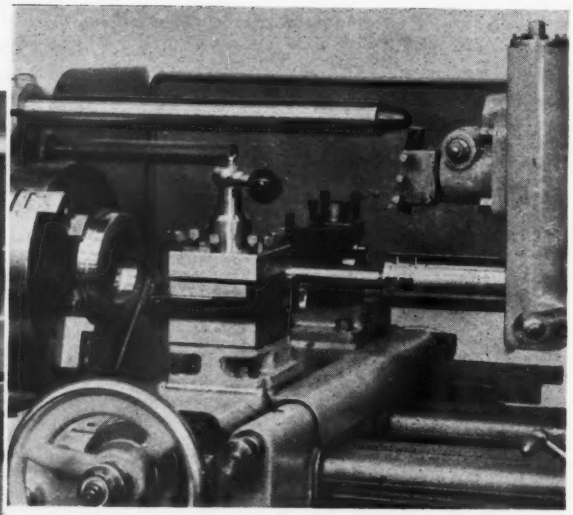

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No. 7 TURRET LATHE

FITTED WITH 12in TUDOR 3-JAW CHUCK

STEEL FORGING

40 Ton Tensile Steel
En.8.

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Grip Forging in Three-Jaw Chuck	—	—			
2. Turn Outside Diameter	—	Front 1	416	765	266
3. Undercut and Face Flange and Chamfer	—	—			
°/dia.	—	Front 2	416	765	Hand
4. Screwcut °/dia. × 11 T.P.I. (7 cuts)	—	Front 3	280	495	11 T.P.I.
5. Face End	—	Front 1	675	1193	52
6. Bore, Undercut and Chamfer	1	—	416	408	134
7. Screwcut Internal Thread 11 T.P.I.	—	—			
(7-cuts)	—	Rear	416	408	11 T.P.I.
8. Remove Part from Chuck	—	—			

All Tungsten Carbide Cutting Tools

Total Floor-to-Floor Time for above operations: 5 minutes.

NOTE:— Time for cutting external thread 11 T.P.I. (7 cuts) 40 seconds
Time for cutting internal thread 11 T.P.I. (7 cuts) 36 seconds

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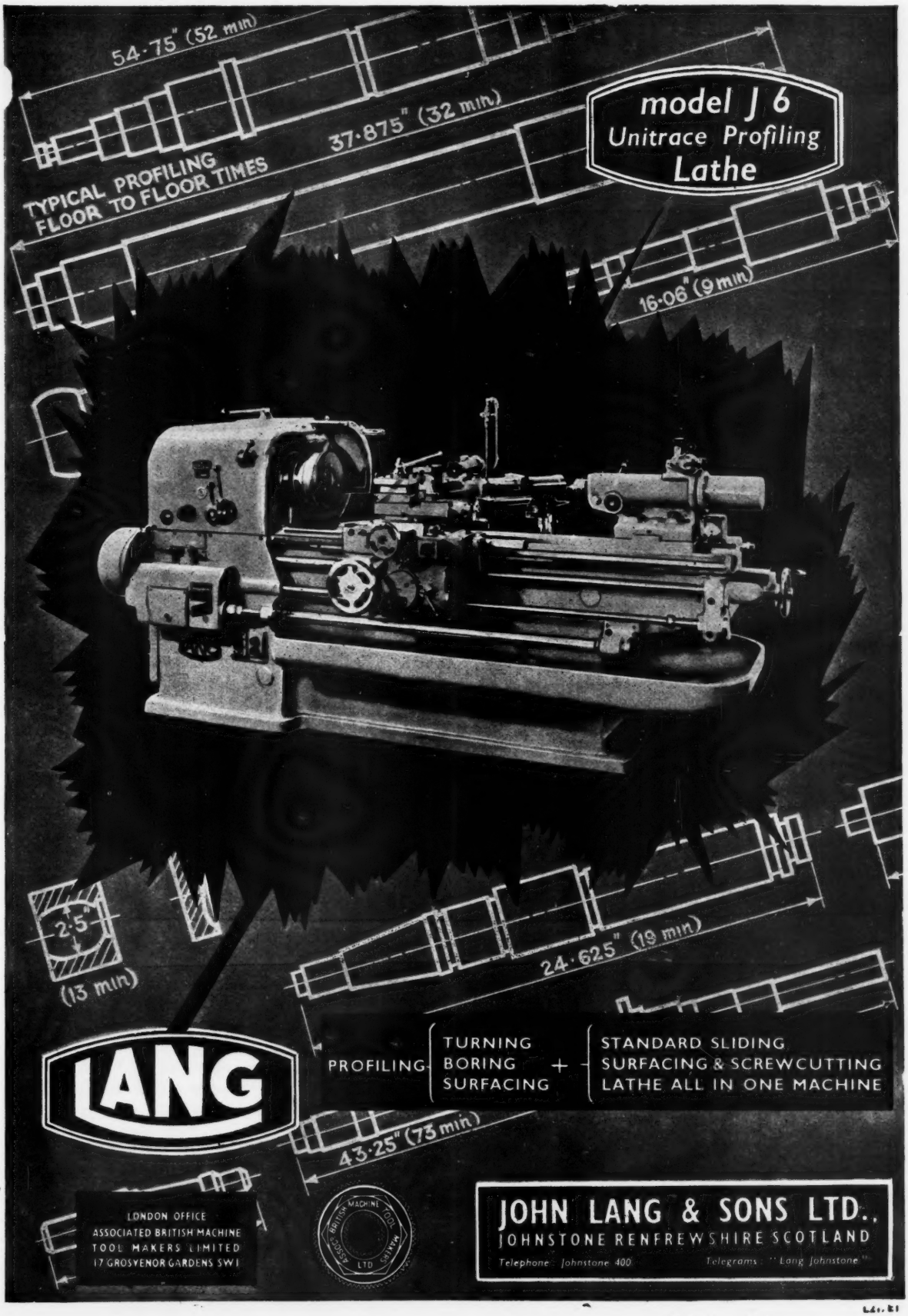
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(13 min)
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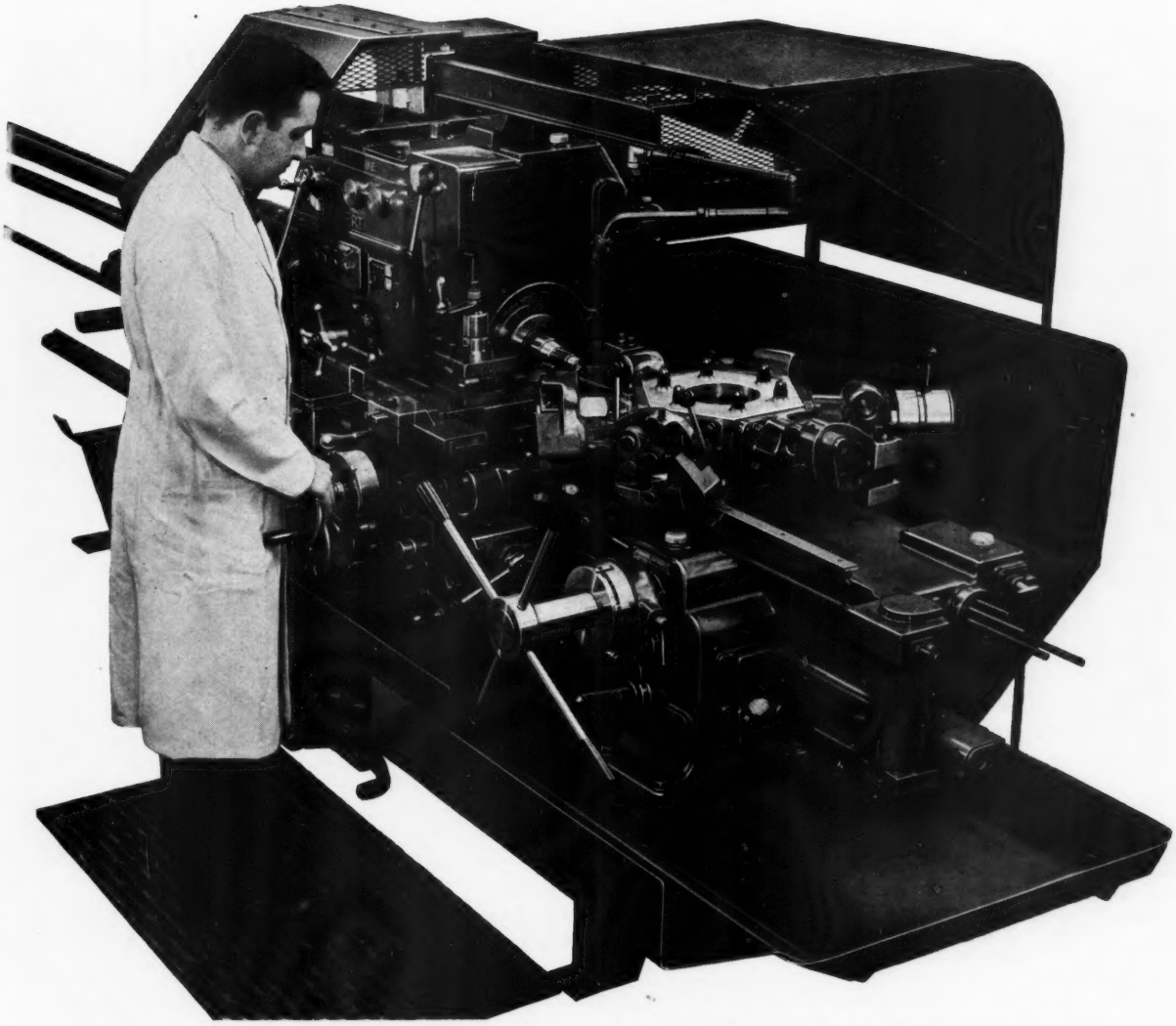

Maximum swing ..	..	15½"
Bar work up to ..	..	2¼"
H.P. of motor ..	..	10
16 *speeds* ..	21-1500	*r.p.m.*

The machine incorporates all the well-known Herbert Lathe features including the power-operated Preoptive Headstock which eliminates idle time due to speed changing. The Headstock contains large clutches capable of transmitting ample power throughout the entire speed range. Automatic sliding and surfacing saddle with or without chasing and taper-turning attachments. Feeds to saddle independently reversible to those of the capstan slide. Chasing mechanism, when fitted, is automatically tripped.

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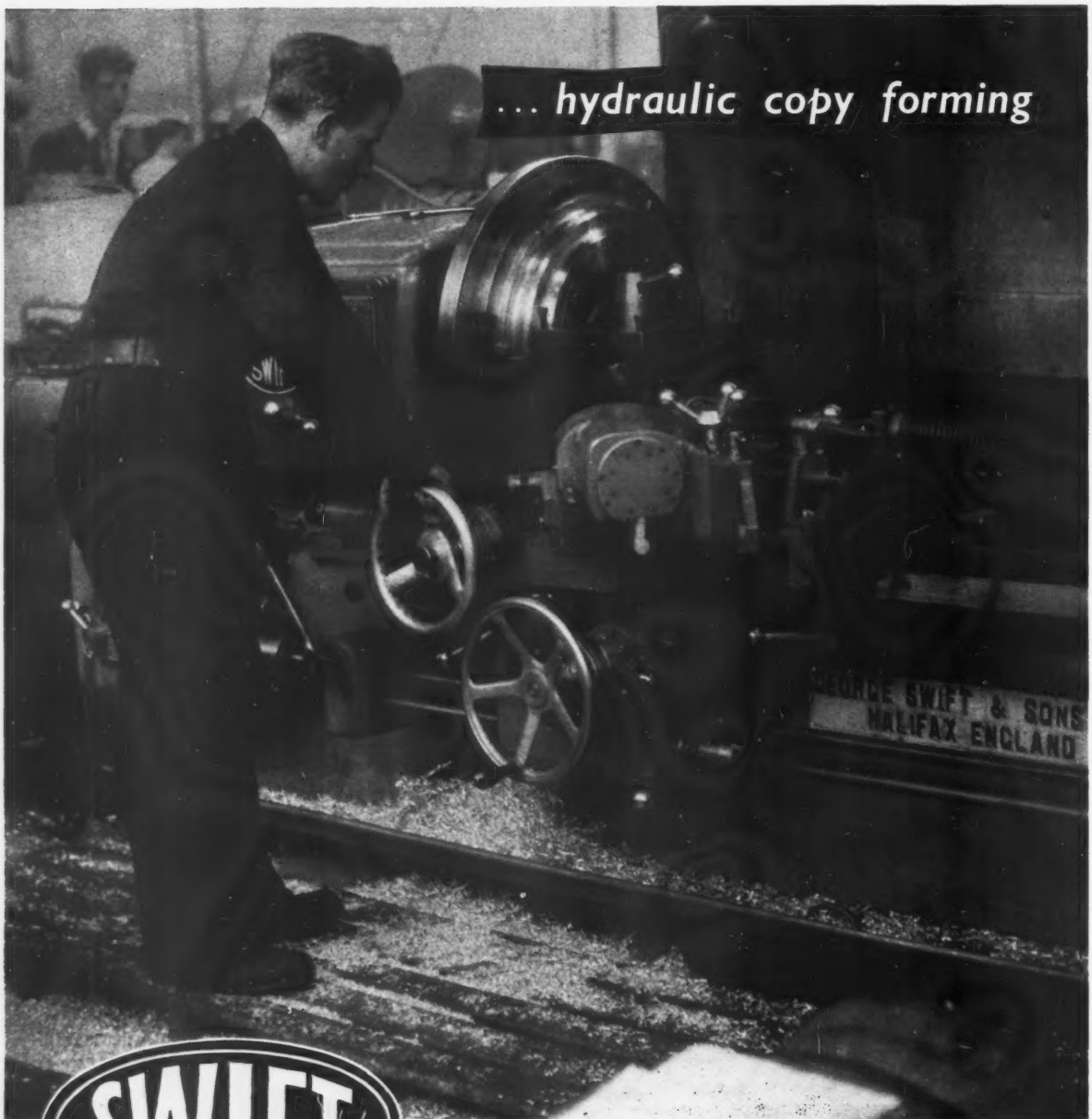

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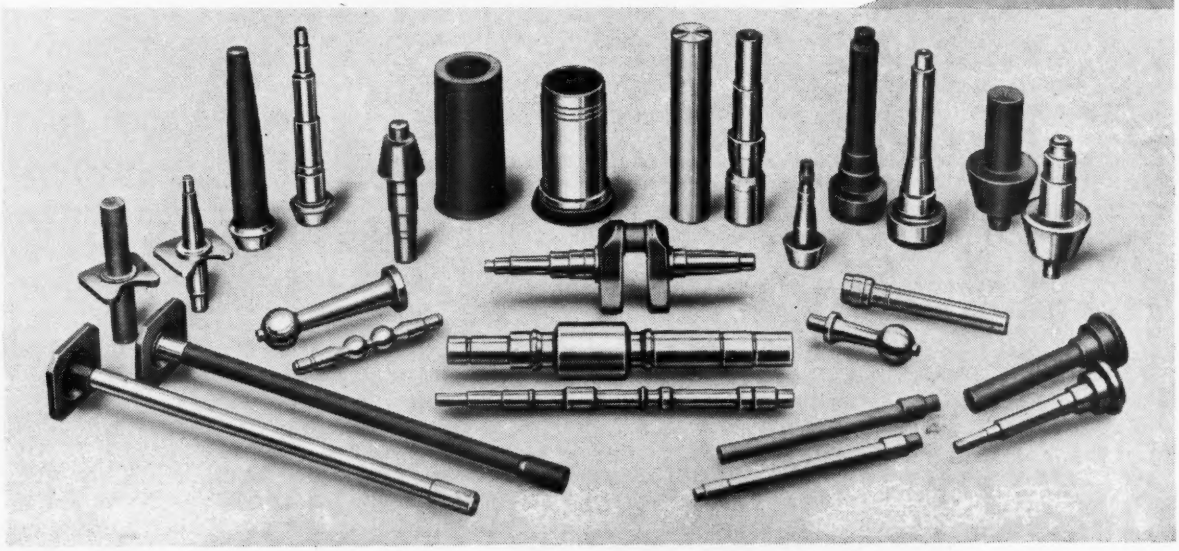

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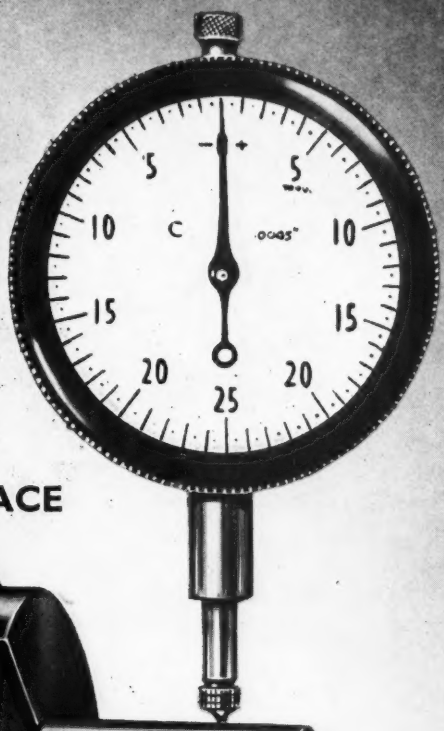

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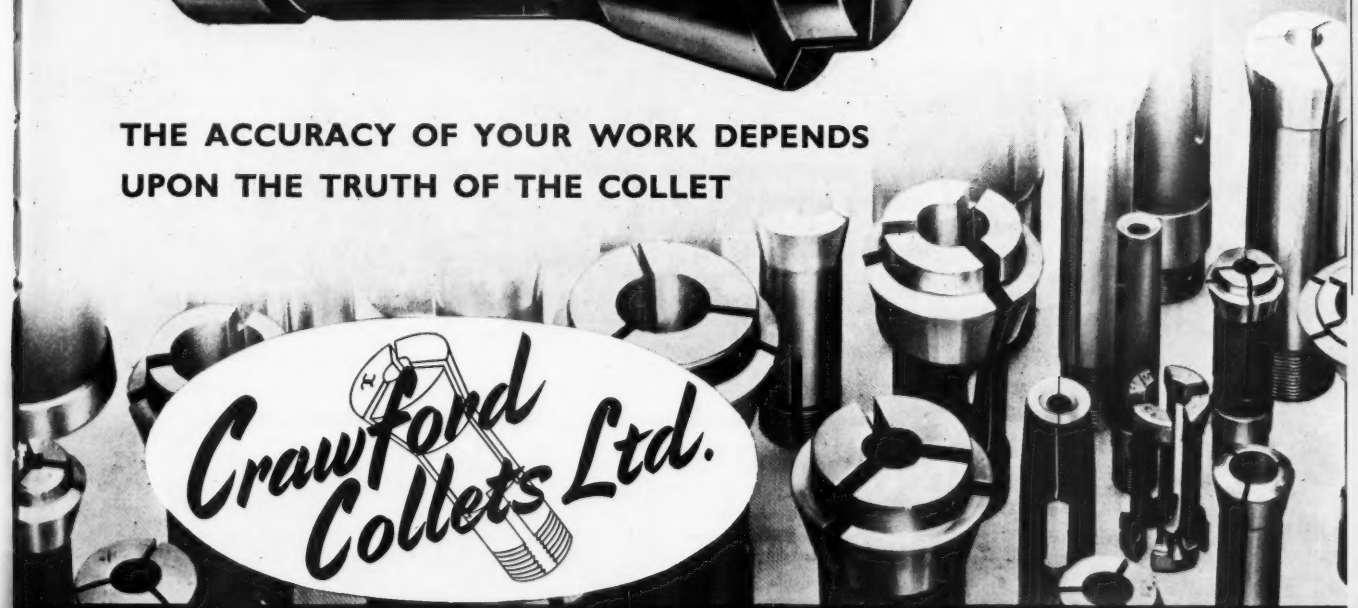

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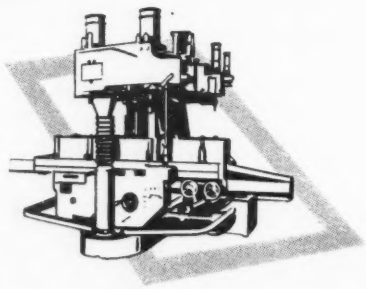

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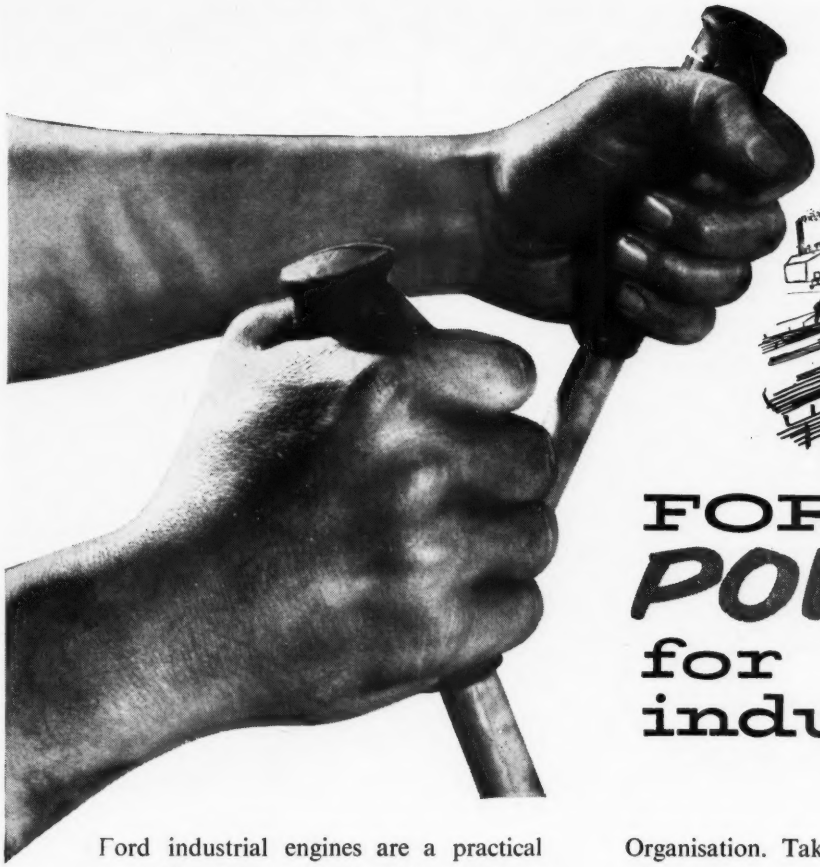

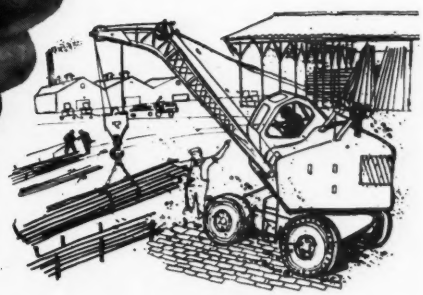

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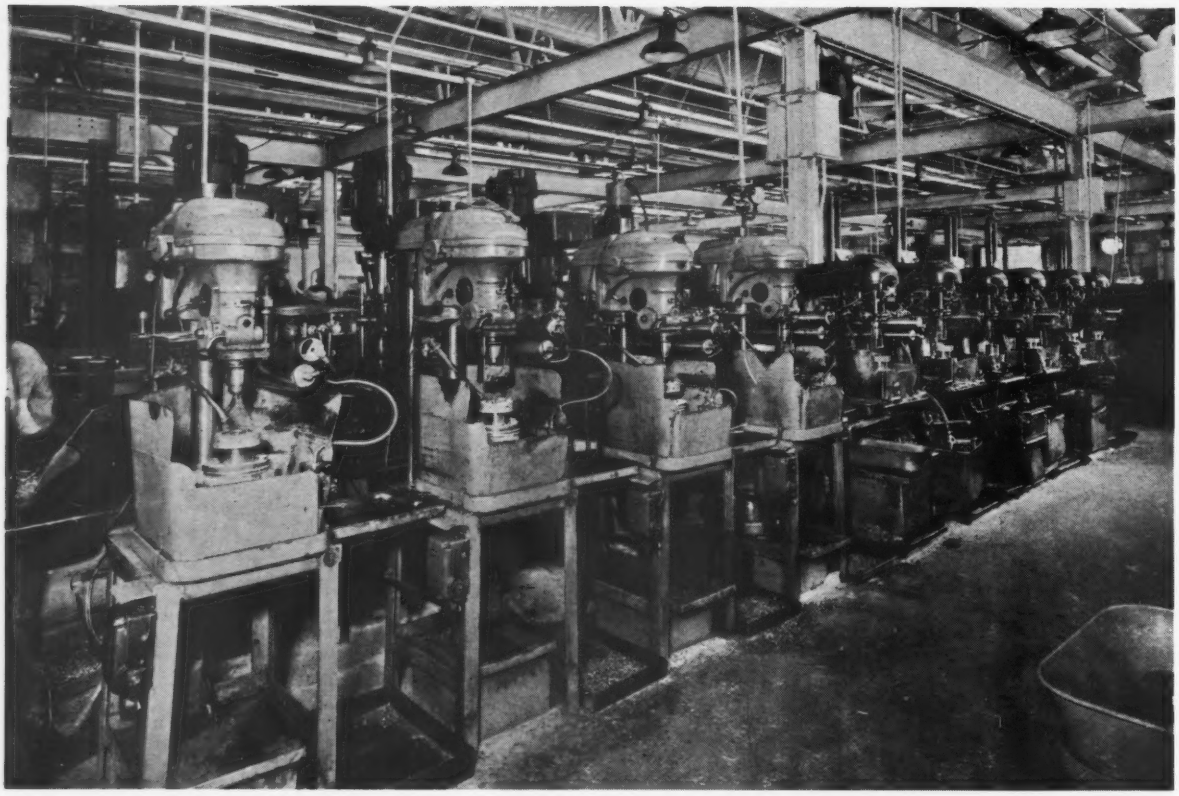

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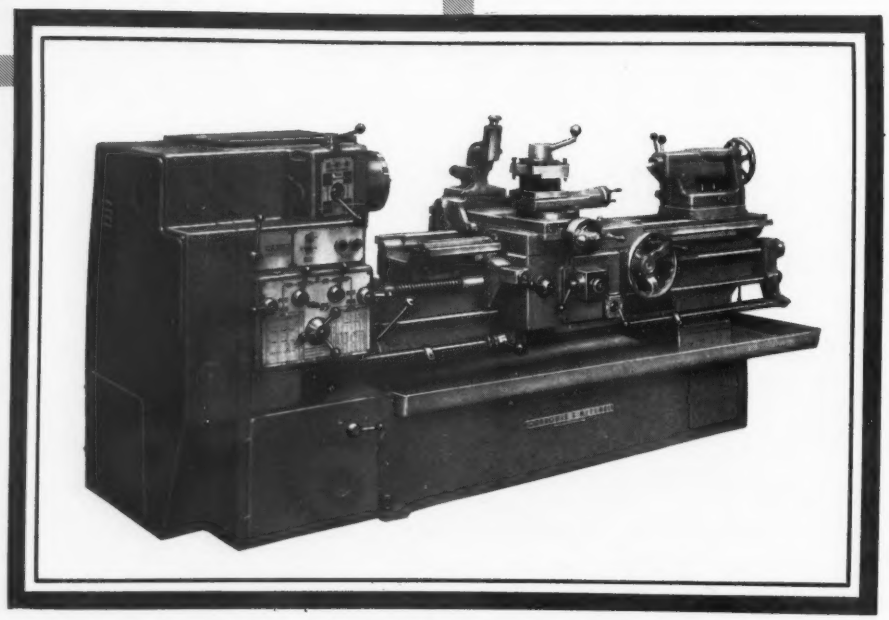

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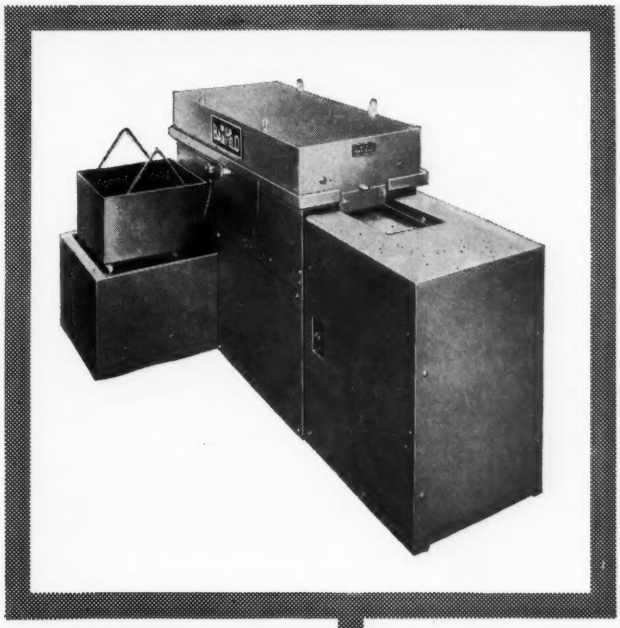

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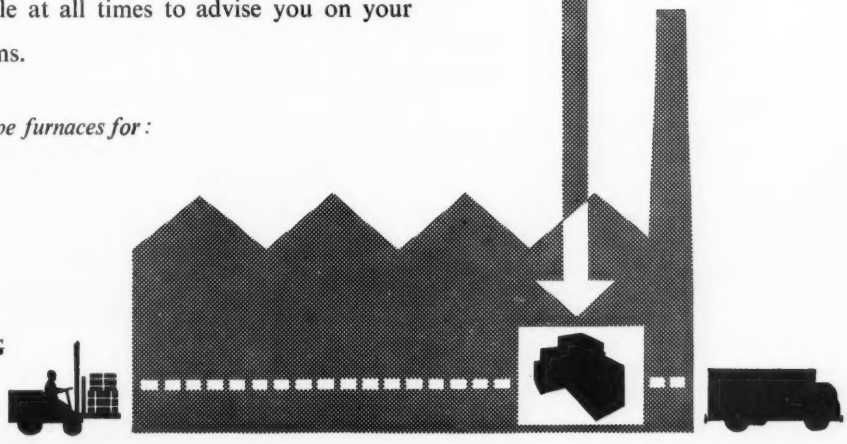

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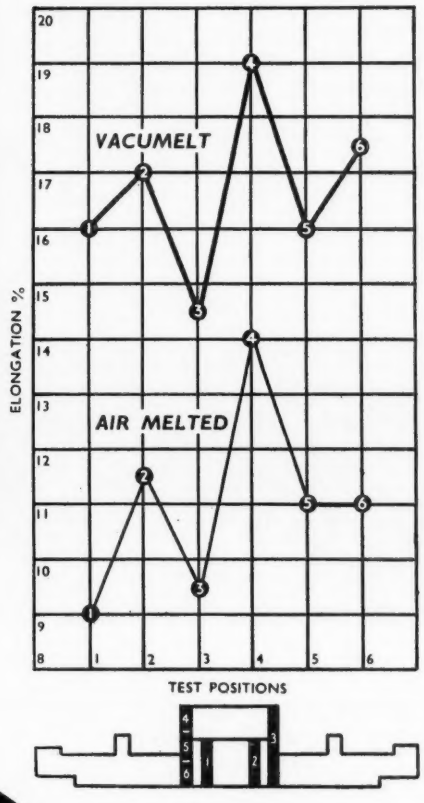

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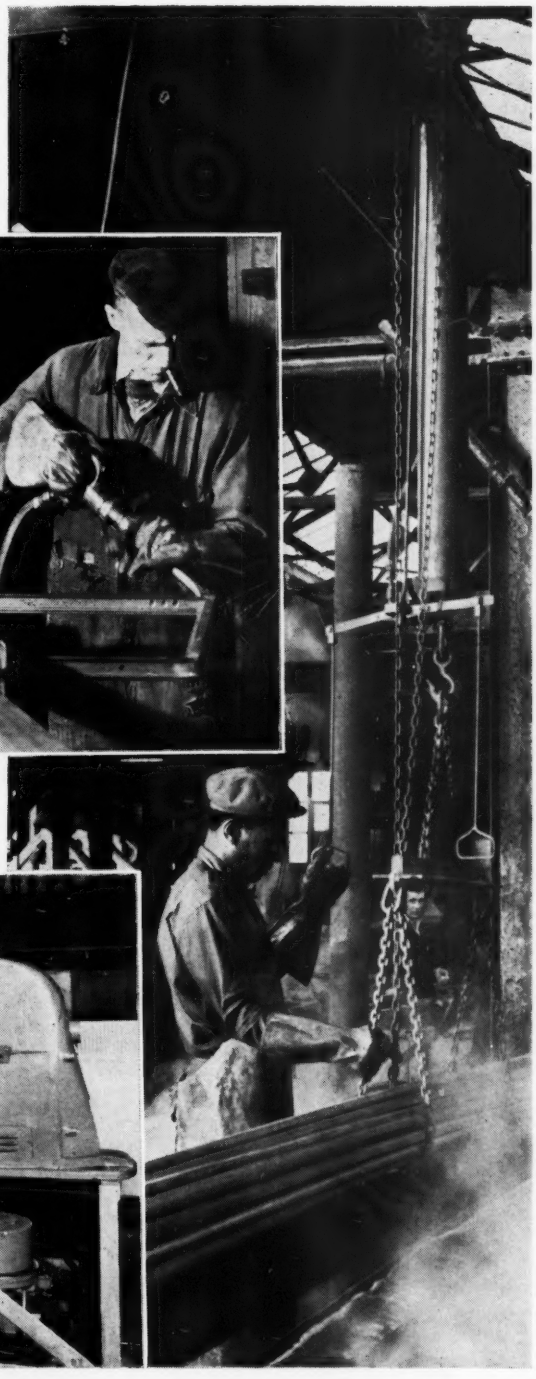
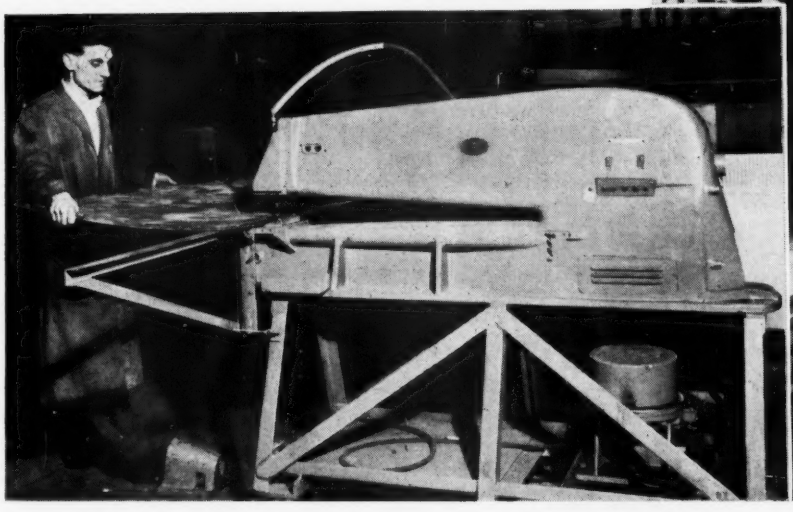


"BROOMWADE" HPS5 Squeeze Riveter counter punching a Bus side stress panel. This tool exerts a 5 ton load at the snaps. Courtesy: Park Royal Vehicles Ltd.



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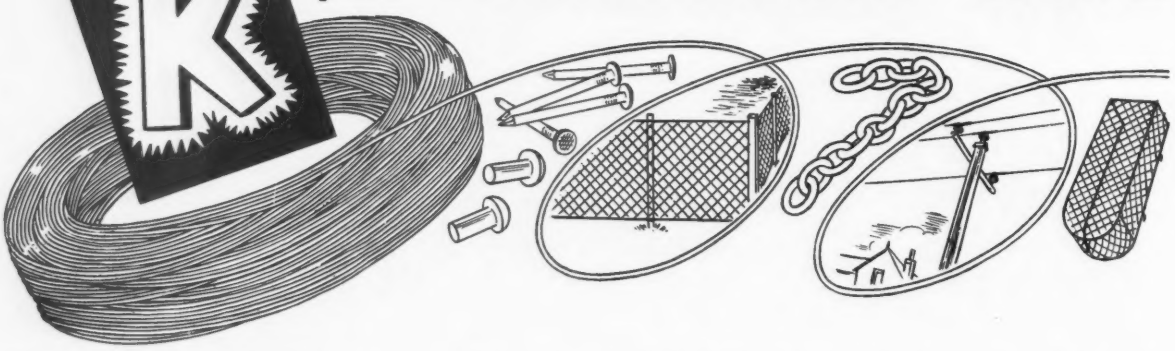

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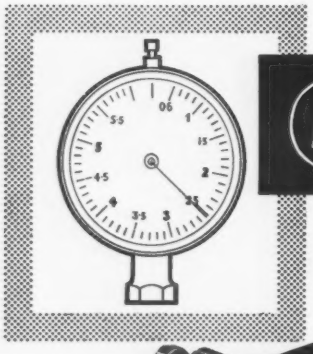

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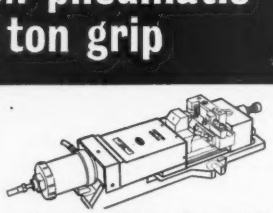

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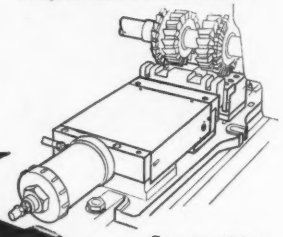

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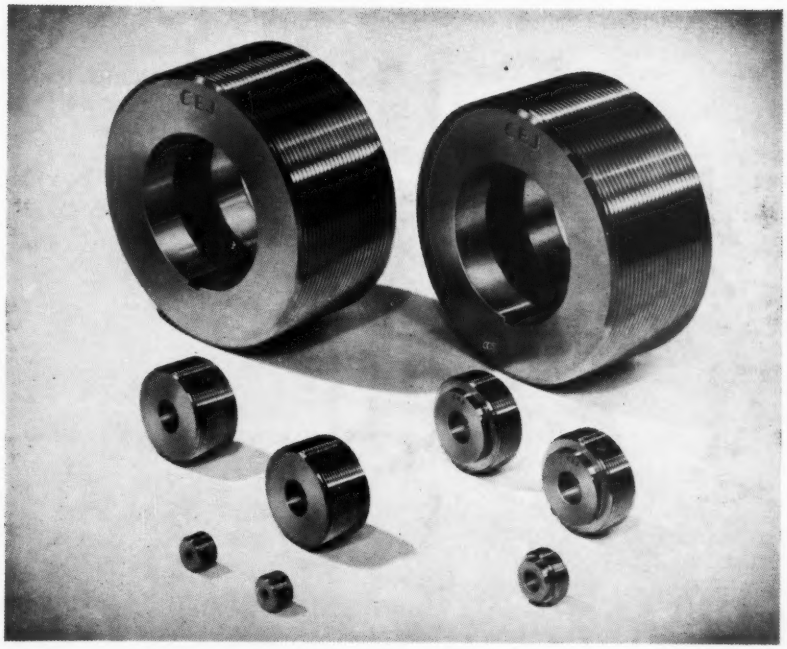

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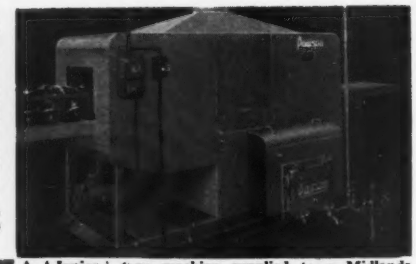

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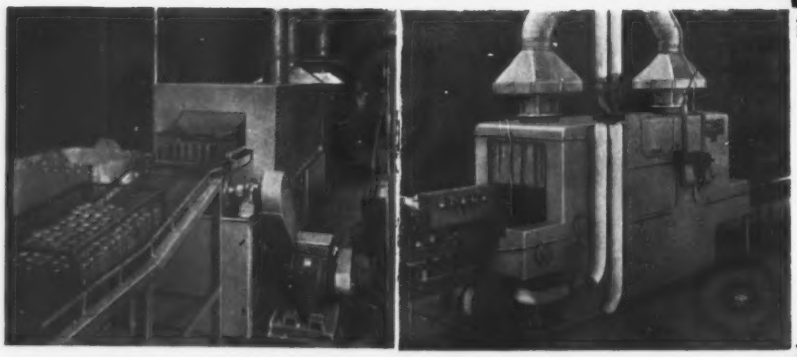

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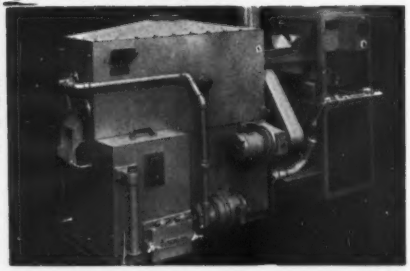

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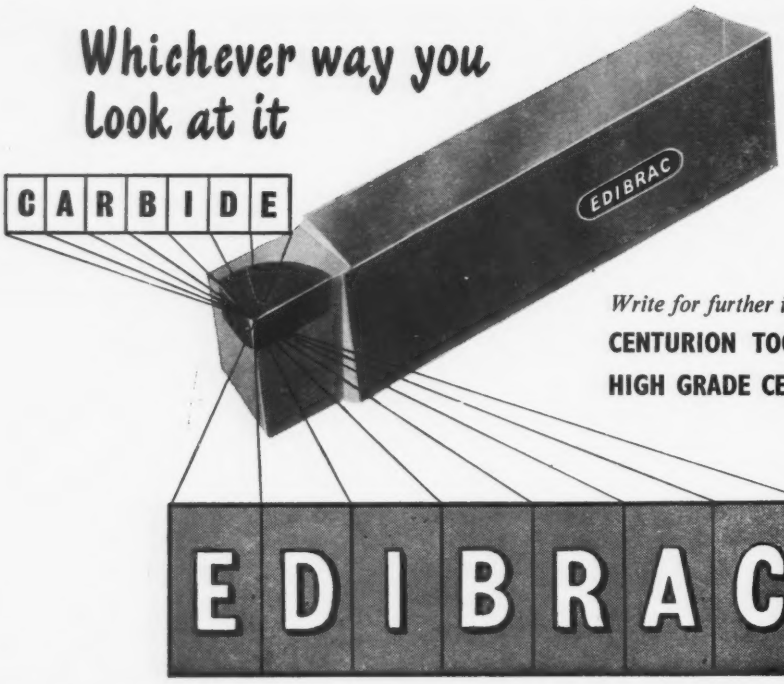

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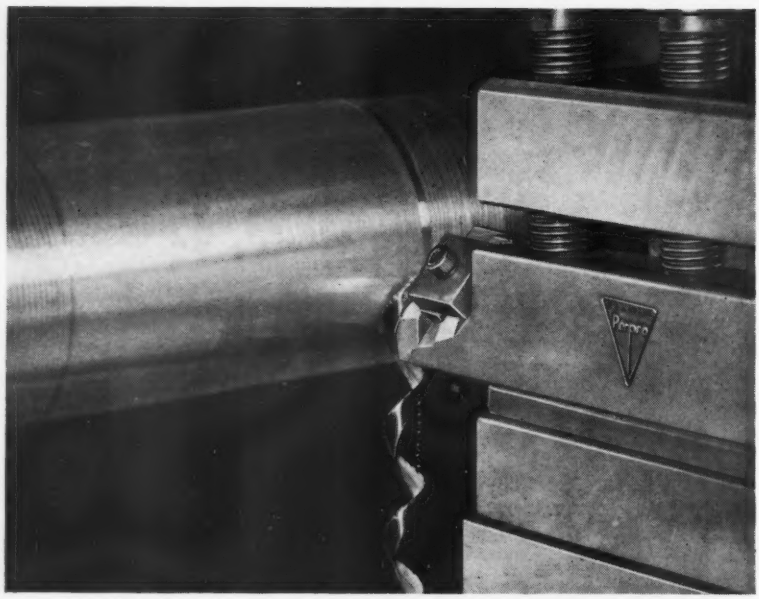
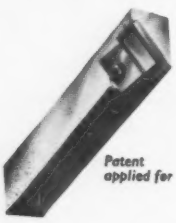


Cross Cross tool cutting S.96, 80-ton steel at 600 ft./min Depth of cut 0.035 in., feed 0.06 in./rev. By permission of the College of Aeronautics.



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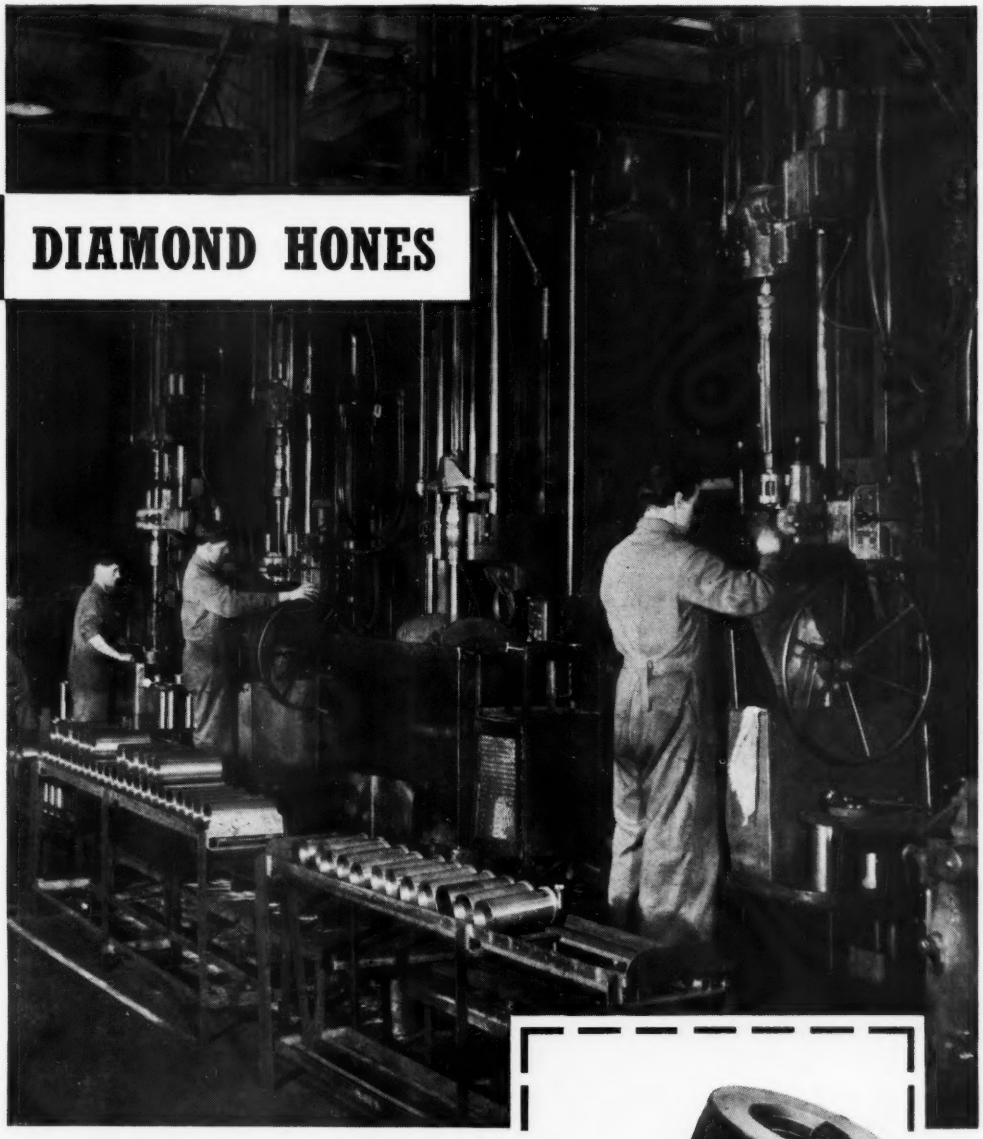

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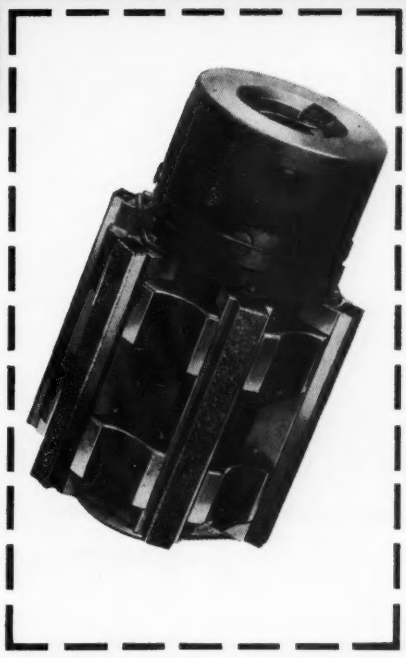

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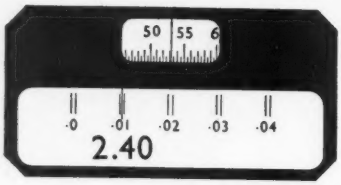

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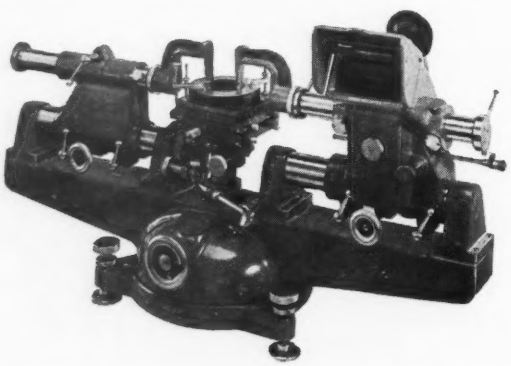

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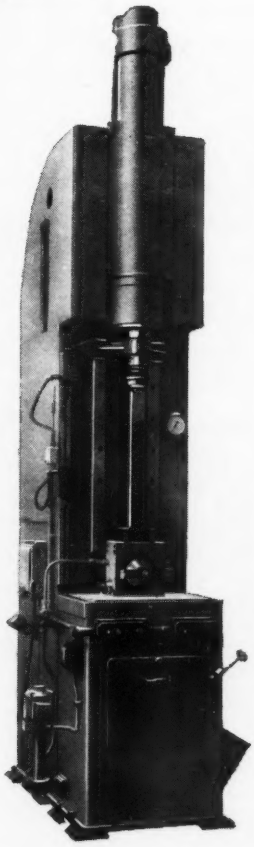

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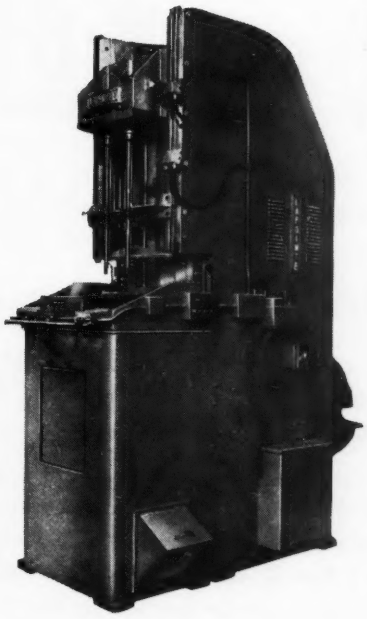

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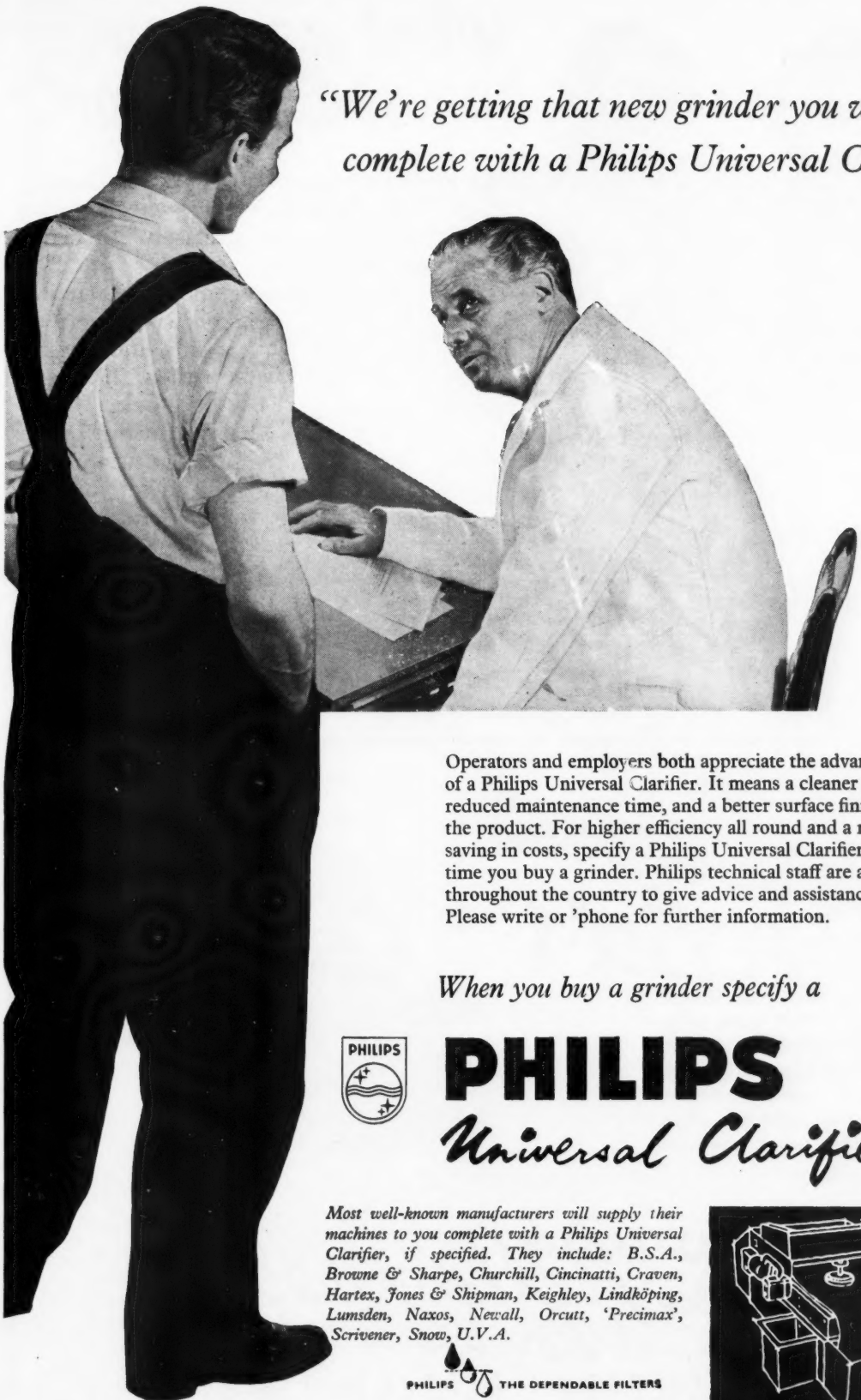

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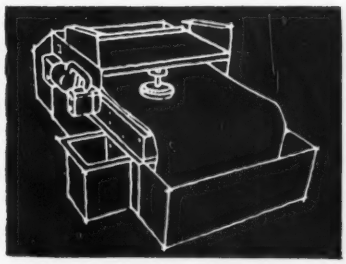

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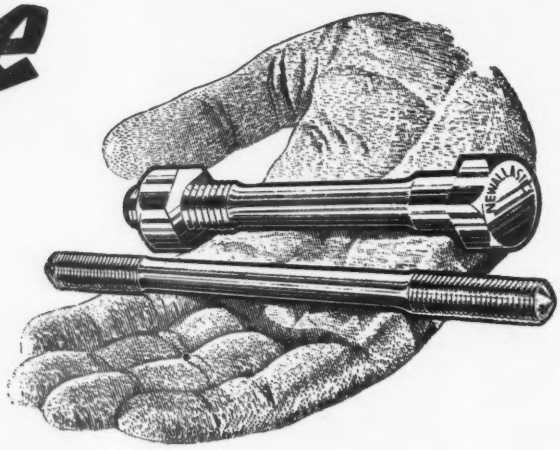

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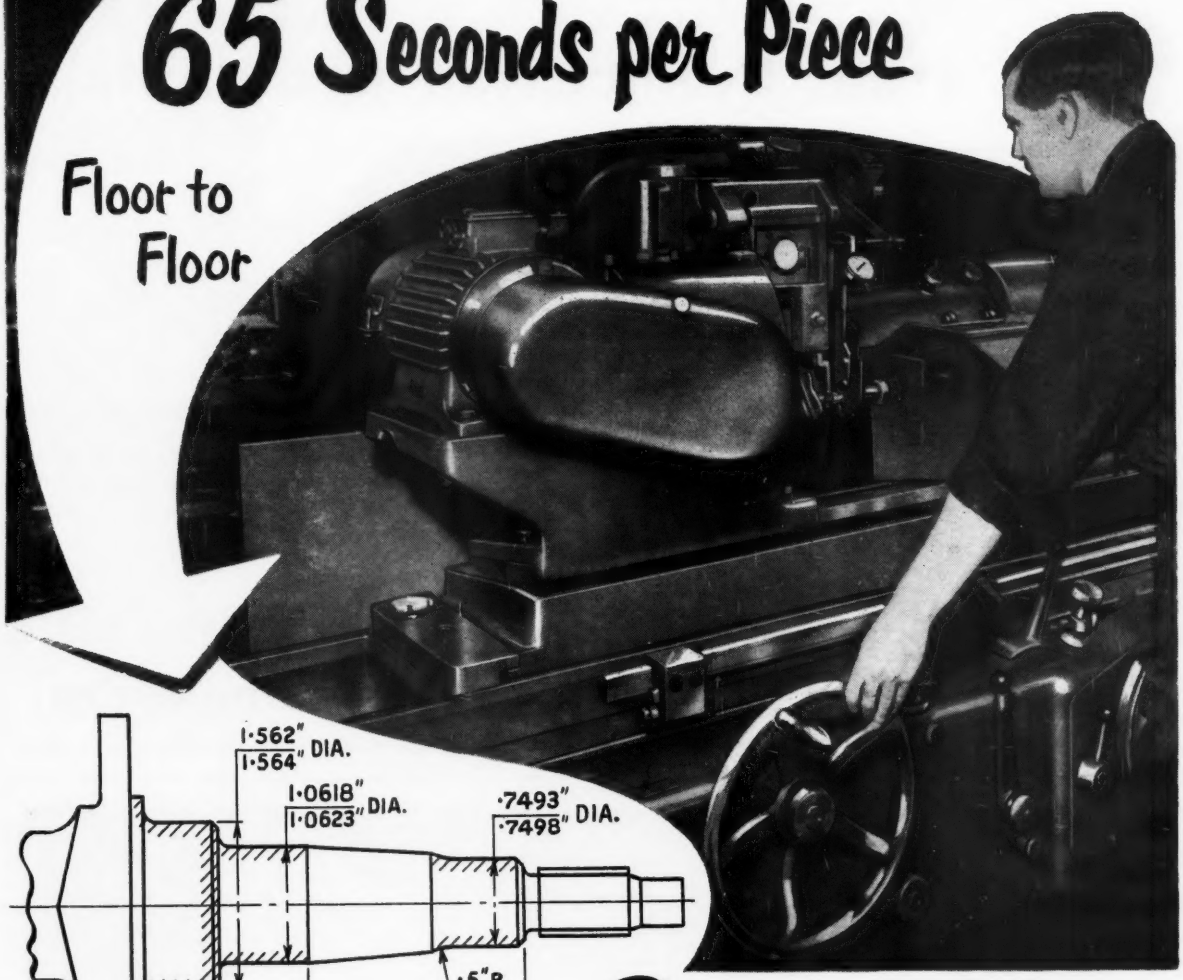

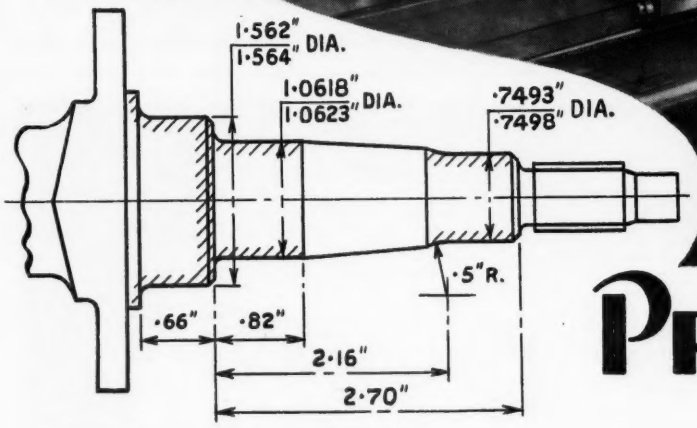

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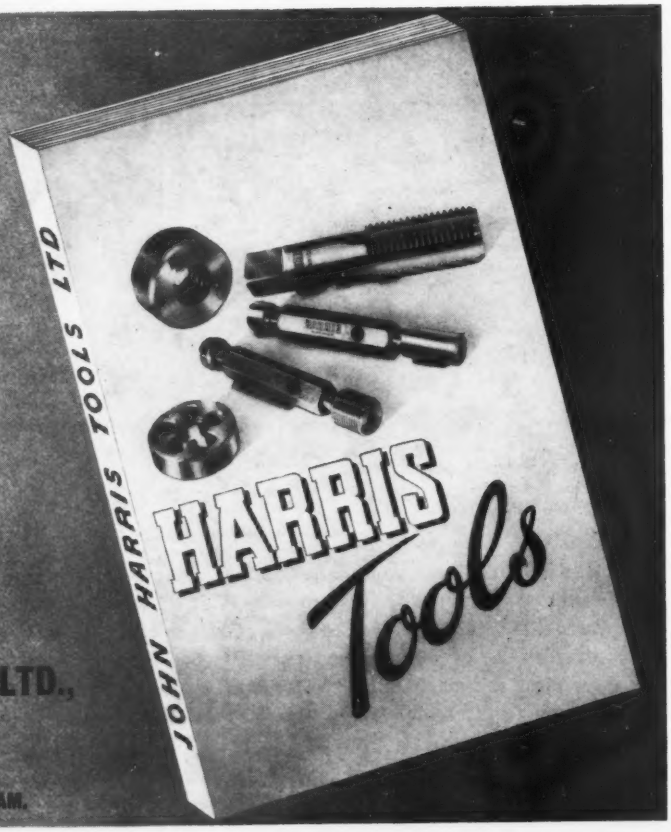

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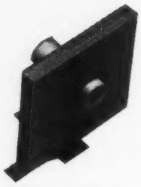
MACHINES AND MATERIALS FOR DRAWING OFFICE PHOTOPRINTING

Illustrating the extreme hardness of SINTOX Industrial Ceramic, the photograph on the right shows a ¼ in. dia. tube of SINTOX which, without even chipping, was forced through a ¼ in. thick mild steel plate.



SINTOX IN ENGINEERING

SINTOX MECHANICAL APPLICATIONS

The many mechanical applications of SINTOX industrial ceramic, will be of immense interest to the designer and mechanical engineer. The remarkable resistance to abrasion of SINTOX makes it particularly suitable for such uses as inserts and supports at points where rapid wear presents a problem. Already it has made a name for itself in the Textile industry, where the advent of artificial fibres brought entirely new problems. Thread guides made of SINTOX have been proved to have up to a hundred times the life of those made of hardened steel.

THE HARD CERAMIC **SINTOX**

STAS

Sintox Technical Advisory Service

This service is freely available without obligation to those requiring technical advice on the application of Sintox Industrial Ceramics. Please write for booklet or any information required enclosing blue print if available.

SINTOX IS MANUFACTURED BY **LODGE PLUGS LTD RUGBY**

PATENT CALIPER GAUGE MODEL 52

Each month one of the seven main advantages of this fine precision instrument will be described.

- Many different gauging positions can be obtained.
- The anvils are set so that they do not roll.
- All shearing action is eliminated.
- ★ Particularly suitable for gauging shouldered work.
- Can be used for either left or right hand threads.
- Particularly suitable for the gauging of acme forms of thread.
- Can be supplied for "GO" only, or "NOT GO" only, or both "GO" & "NOT GO" combined.

NOTE THIS MONTH'S IMPORTANT FEATURE

★ **PARTICULARLY SUITABLE for GAUGING SHOULDERED WORK**

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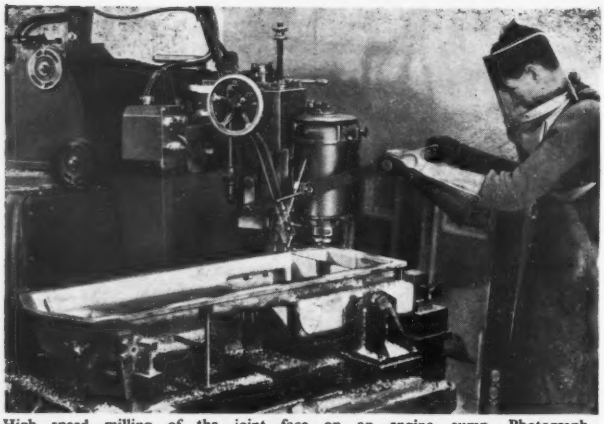
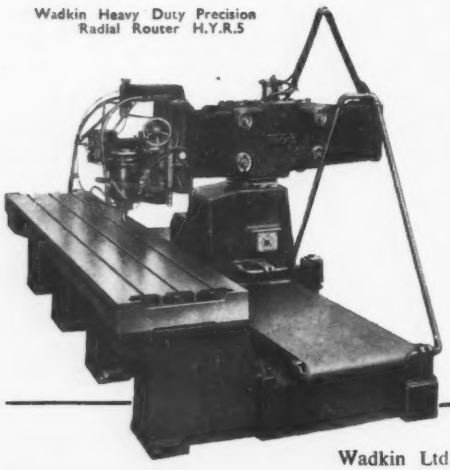
Rainbow 1838

Revolutionising machining times on NON-FERROUS METALS



High speed milling of the joint face on an engine sump. Photograph by courtesy of Messrs. Rolls-Royce Ltd., Oil Engine Division, Derby.

Wadkin Heavy Duty Precision Radial Router H.Y.R.S



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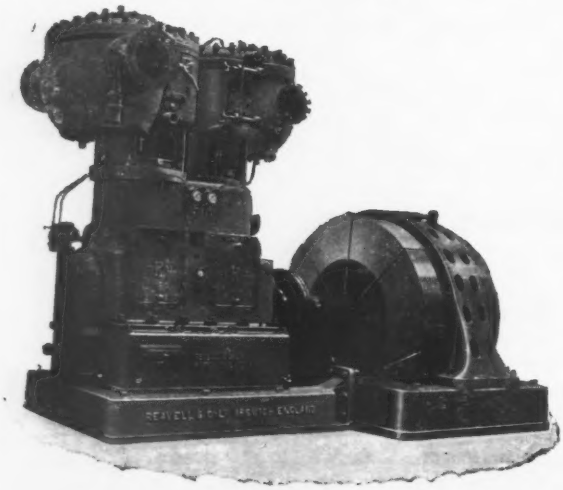

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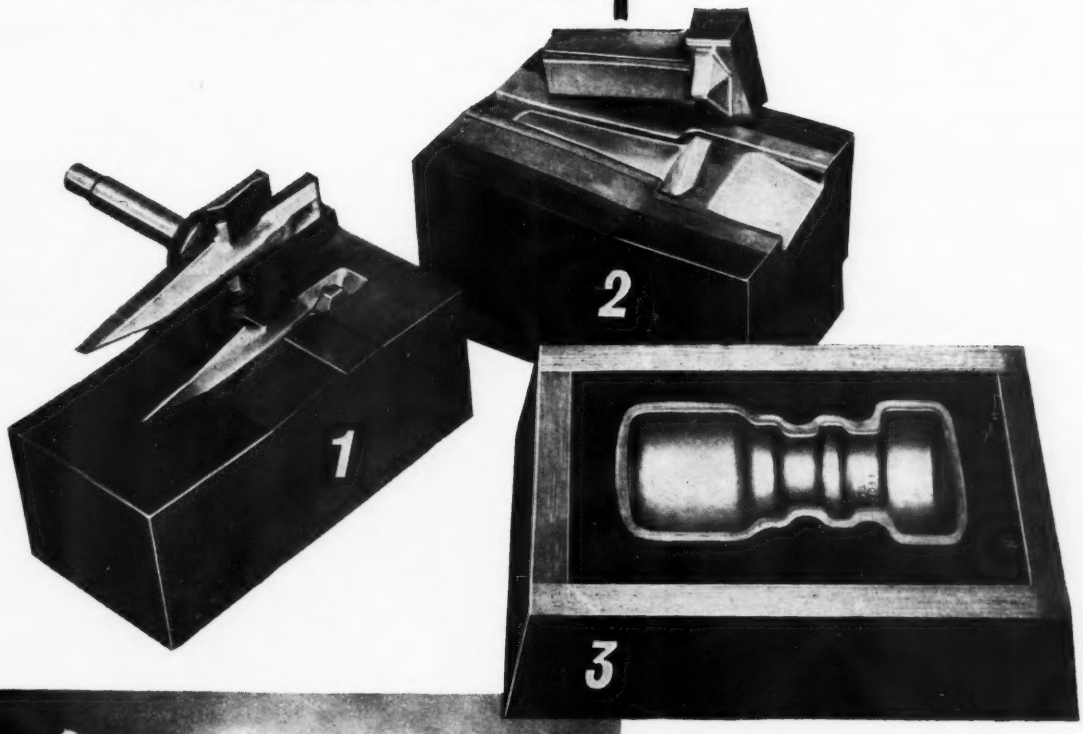

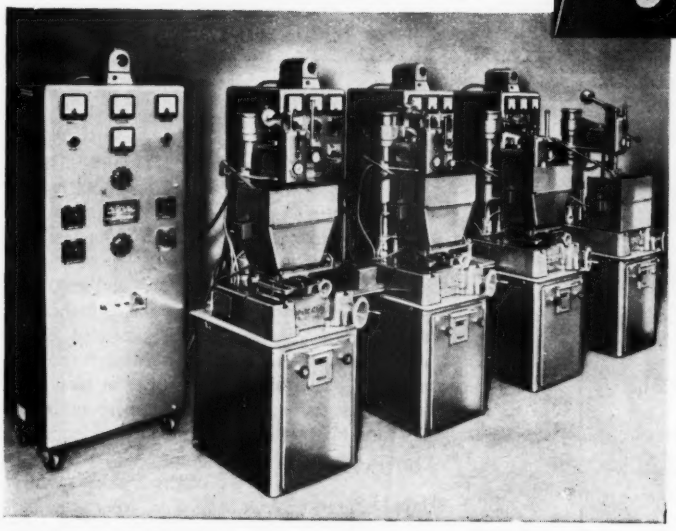

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2 Jet Compressor Blade Forging Die reconditioned by Spark Machining

3 Layshaft Forging Die, preformed and finished by Spark Machining

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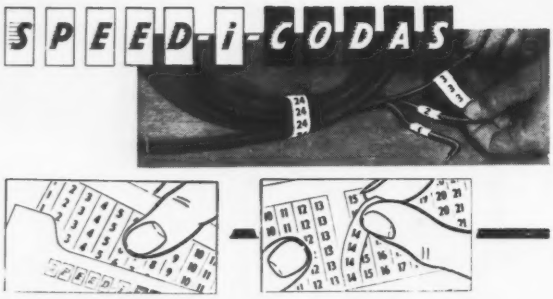

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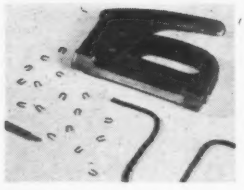

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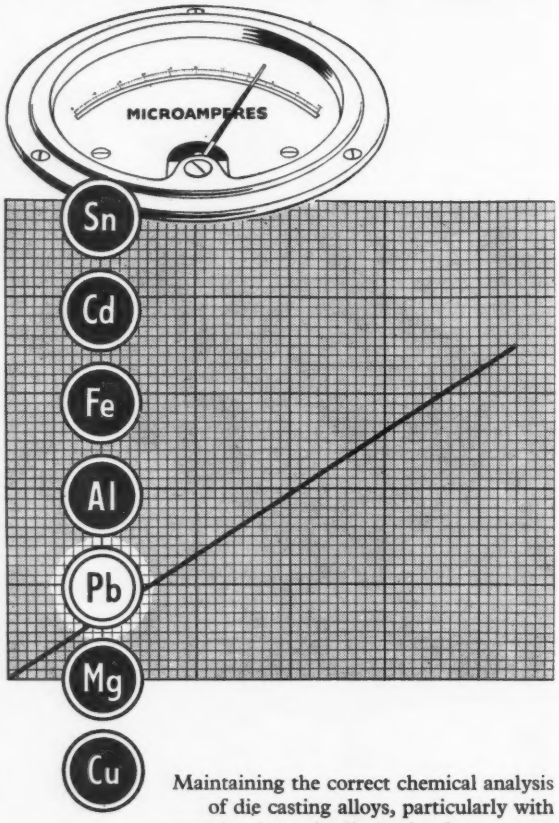
QUALITY CONTROL of pressure die castings



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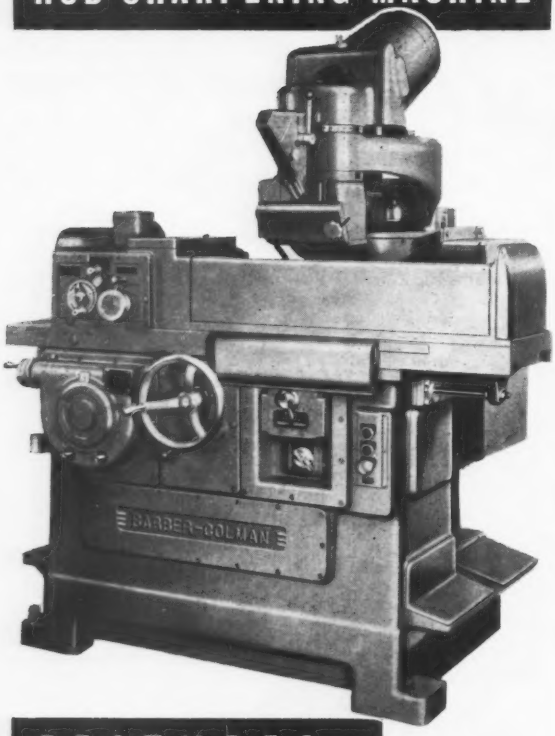

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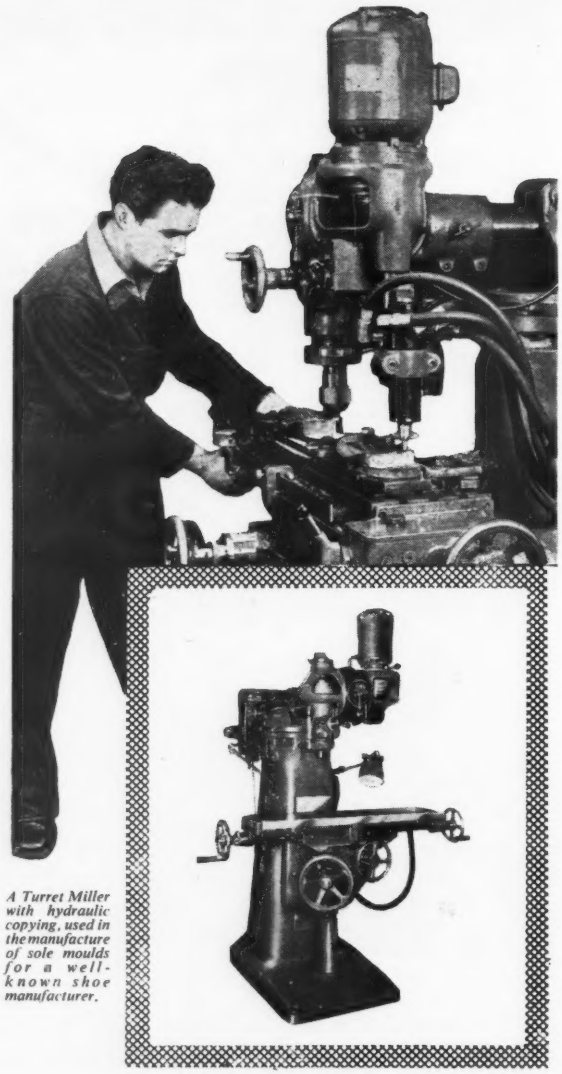

A Turret Miller with hydraulic copying, used in the manufacture of sole moulds for a well-known shoe manufacturer.

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FOR CRITICAL ACCURACY
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Table surface 38″ × 9″; 24″ longitudinal, 9″ cross, 14″ vertical traverses. Eight spindle speeds 130 - 4100 r.p.m. Automatic hydraulic tracer controlled model copies patterns to high degree of accuracy by synchronised movement.

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Seven steels, developed by Edgar Allen to meet the varying requirements of moulds and hobs for plastics. ★

Extensive research was undertaken in conjunction with famous manufacturers of plastic mouldings before the specifications were finalised to ensure that every possible requirement was met by one or other of the seven.

To make choice of the correct steel easy and certain, Edgar Allen have produced a booklet, which not only gives full details of each steel but also details of the plastic powders for which they are suitable or of the hobbing conditions, with instructions for heat treatment. For a copy of this invaluable booklet write for Publication 41C.

★ The seven steels are :-

A13 Mould Steel — for cut moulds and shallow hobs.

Edgar Allen Plastic Hobbing Steel — a general purpose hobbing steel.

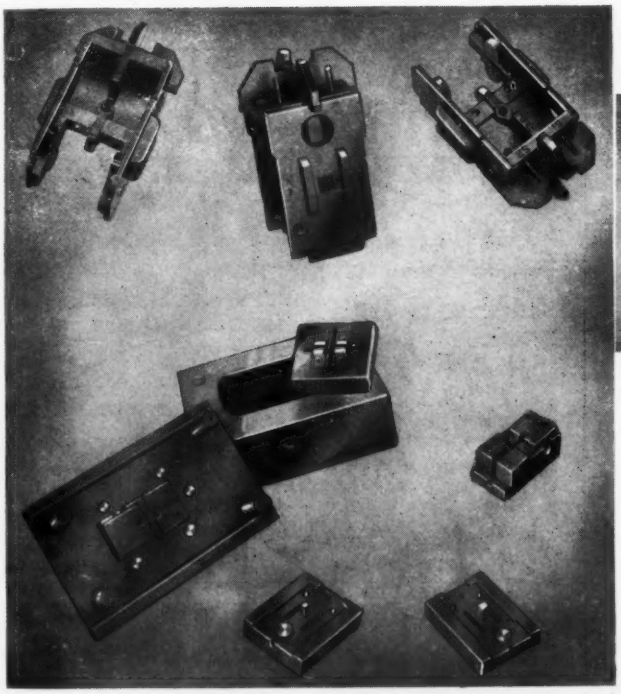
Double Six Master Hob Steel — non-shrinking, through-hardening.

Imperial Stainless Mould Steel — for cut moulds, but not suitable for hobbing.

A100 Mould Steel — similar to A13 but cannot be hobbed.

Imperial R.1.0 Stainless Hobbing Steel — a special steel used with urea and other staining powder.

Double Six Die Steel — for moulds that must be hard throughout but are not subject to rough handling, and for injection moulds.



Below — Example of moulds and products made by the hobbing process.

Left — Moulded electrical contact block and mould.

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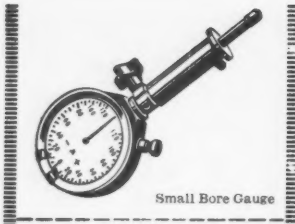
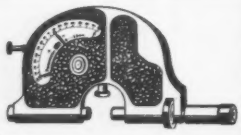


Small Bore Gauge

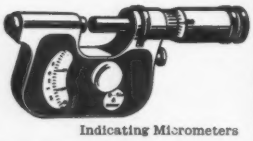
Universal Tool Holder



Passameters

External Micrometers

CARL ZEISS JENA



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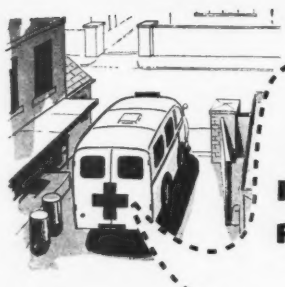

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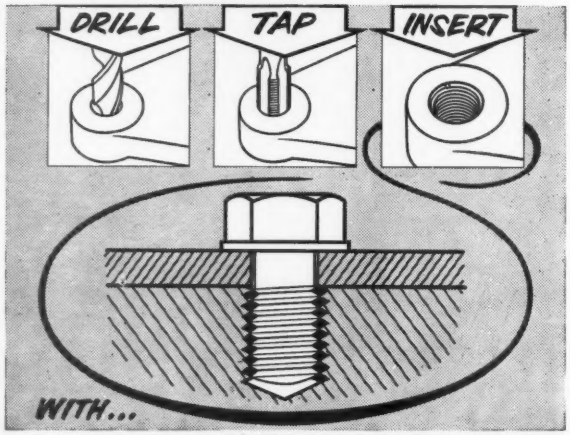

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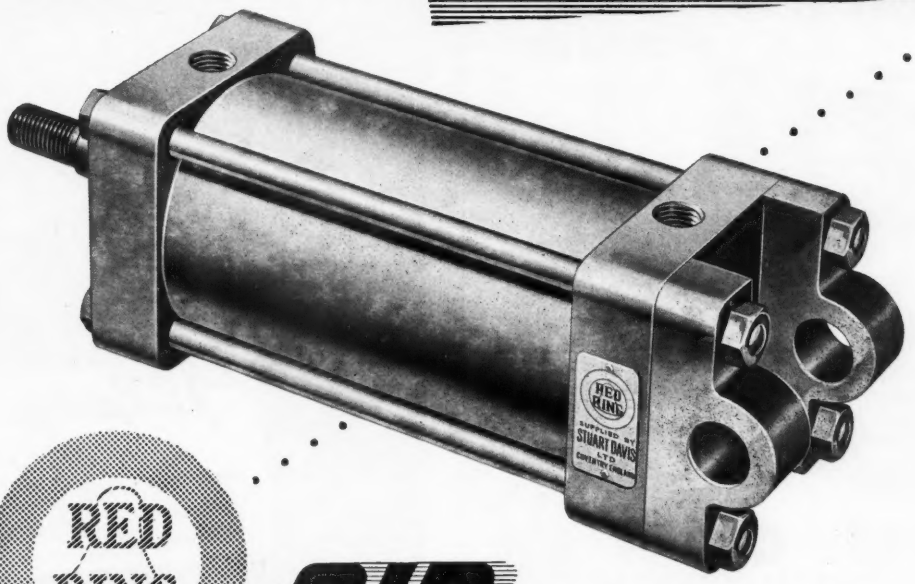

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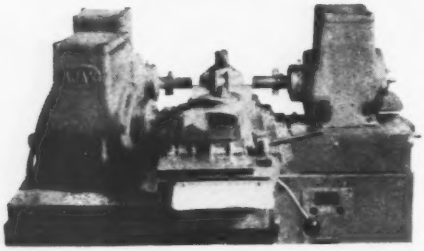

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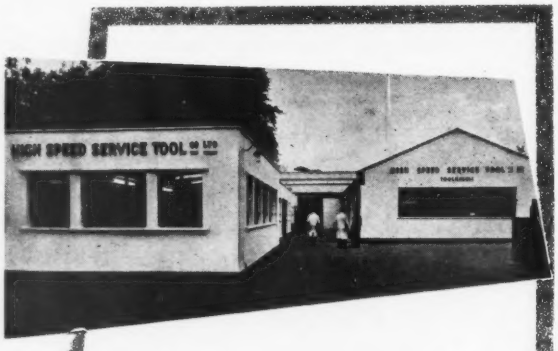

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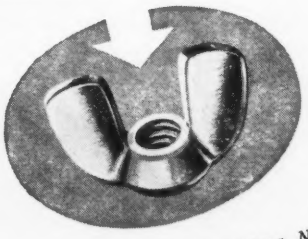

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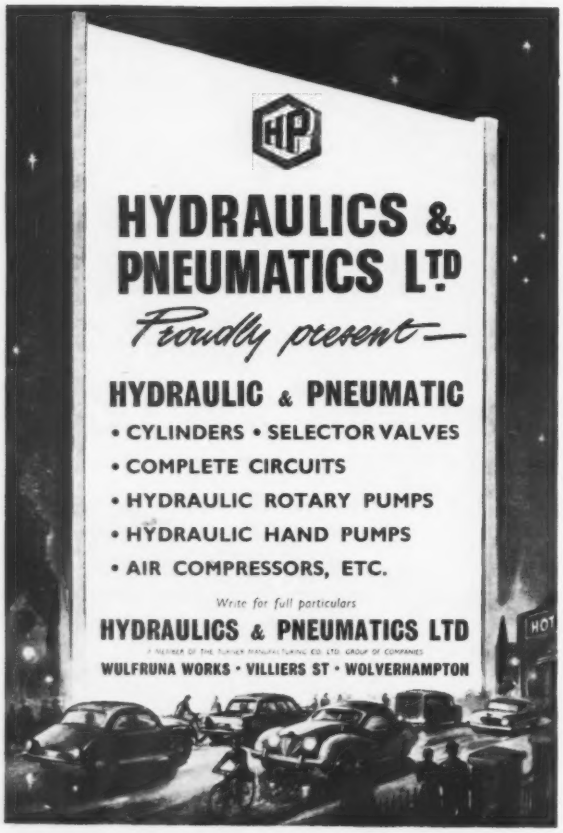

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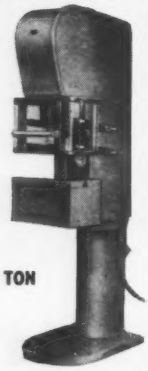

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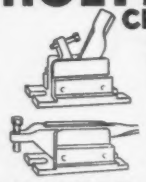

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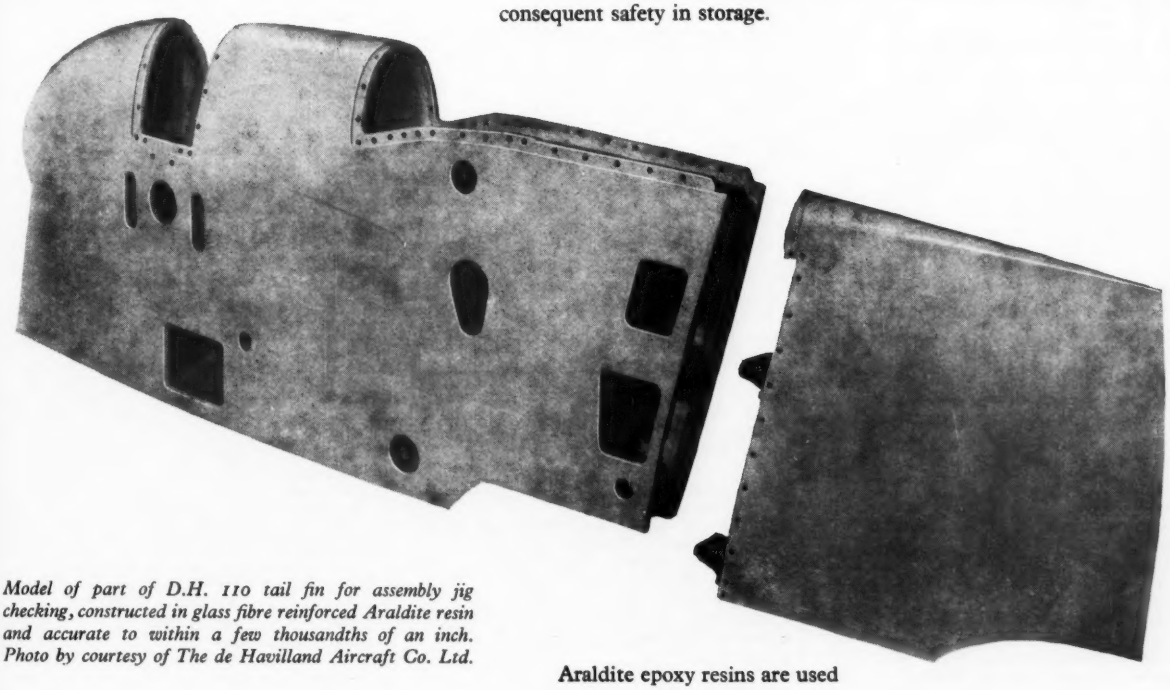

Model of part of D.H. 110 tail fin for assembly jig checking, constructed in glass fibre reinforced Araldite resin and accurate to within a few thousandths of an inch. Photo by courtesy of The de Havilland Aircraft Co. Ltd.

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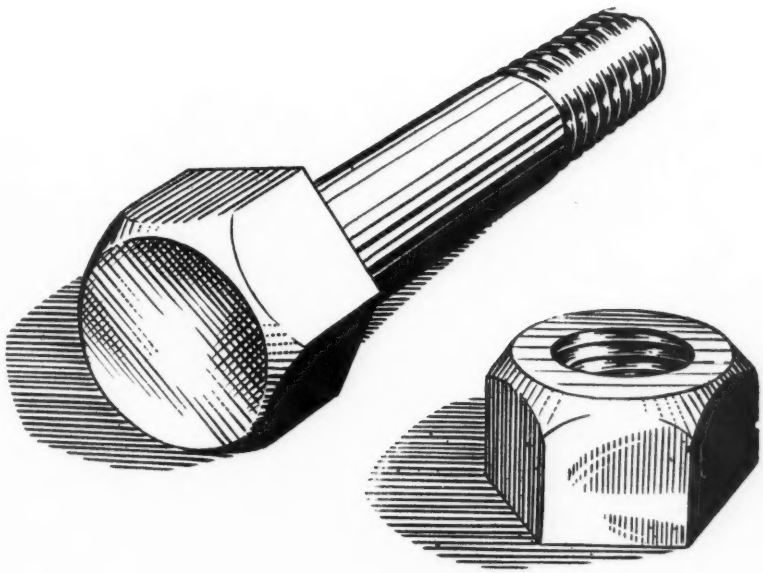

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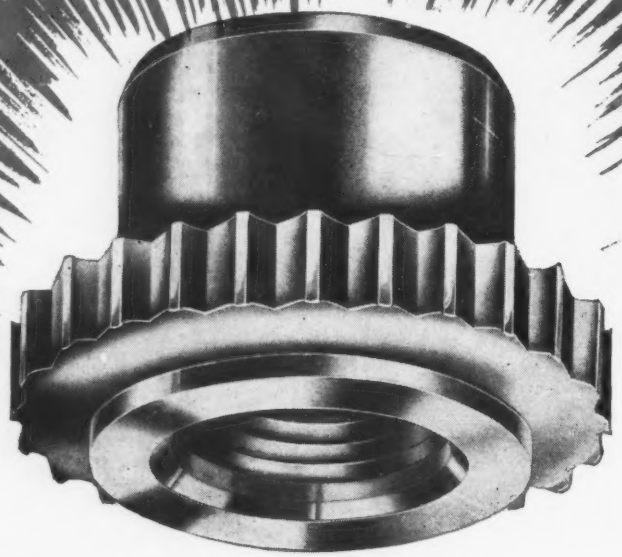

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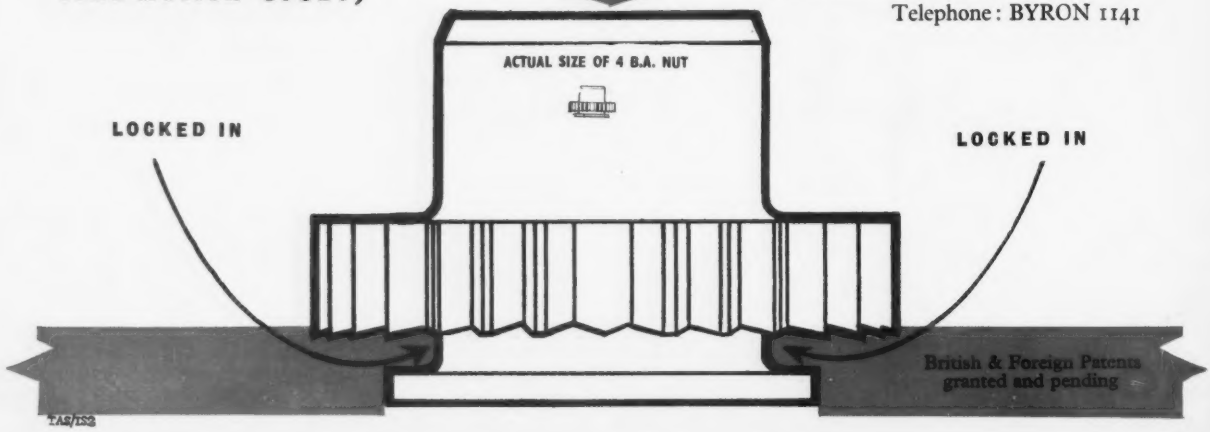
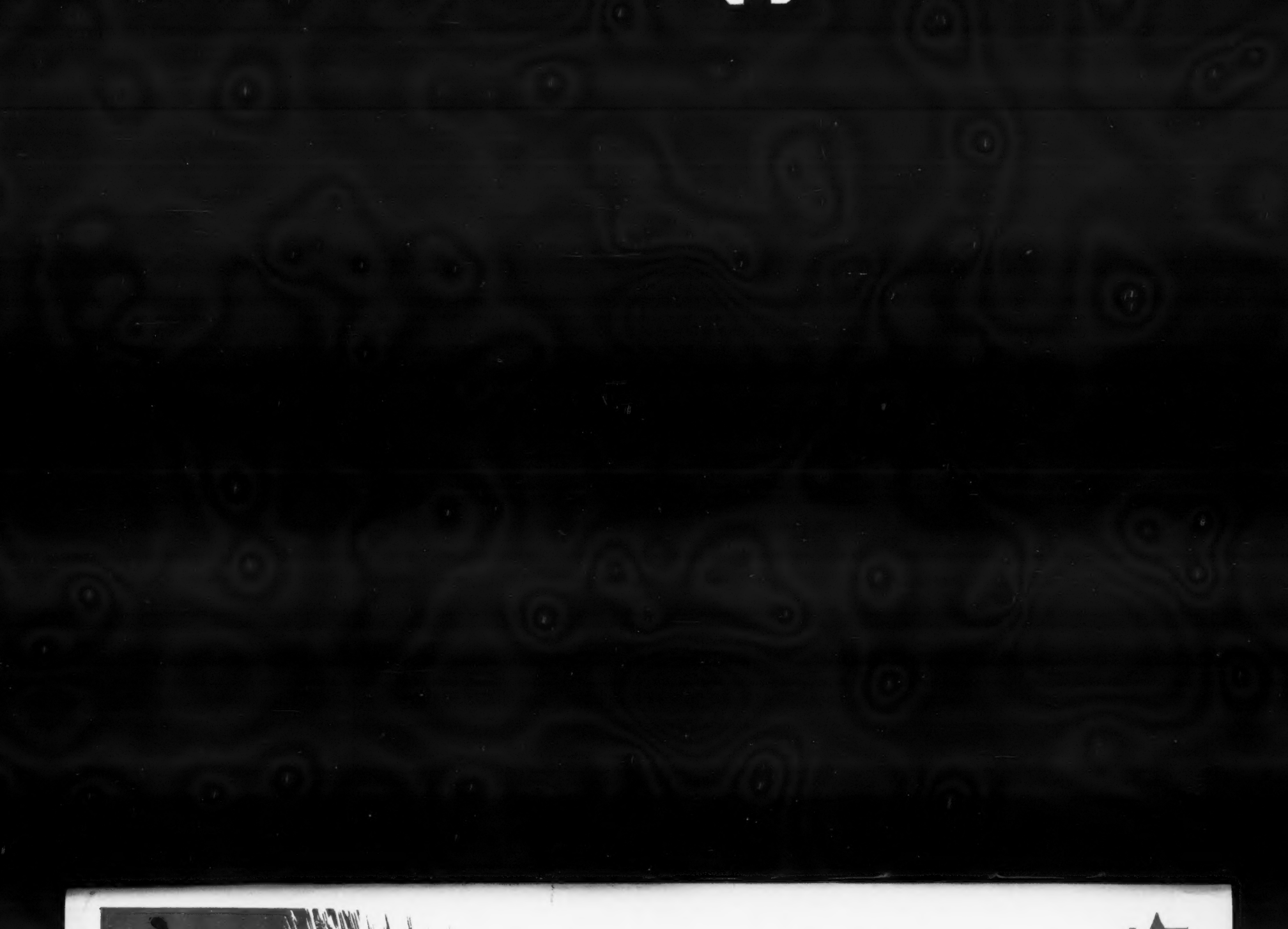
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